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THE TEXT-BOOK IN ELEMENTARY CHEMISTRY.*

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The subject which I wish to discuss with you for a short time is one which has to deal with the text-book in elementary chemistry. To be more specific, the discussion will deal not with the function of the text nor with the part it should play in the course, but rather with what I believe to be some of the requisites of such a text-book as is suitable for use in our secondary schools. I realize that much has been written on this subject and of course we have the views of many prominent teachers as expressed in the texts of which they are the authors. The question is also often touched upon in the reviews of different texts. With all due respect to the reviewers, however, I am learning to place less and less stress on the average review. It is interesting to collect and compare the reviews of the same book. It is an exceptional case when one does not find all shades of opinion expressed, from the one which is highly commendatory to the one which mildly implies that the author owes an apology for having "added one more to the already formidable array of texts." In some cases the reviews plainly show that the reviewer has not studied the book thoroughly enough to be competent to make a criticism of it and a great injustice is often done the author.

First of all, I trust that you agree with me in the belief that a text is an absolute necessity for students in secondary schools. I have no sympathy with any method that seeks to displace a text, even though it be a poor one, with any system of lectures or notes written out for the student or dictated to him.

* Address before the Chemistry Section of the Central Association of Science and Mathematics Teachers, at a meeting held in Chicago, November 27, 1903.

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There are undoubtedly conditions in college and university work when such a system may be rightfully used, but even here I am sure that better results would be obtained if there were fewer lectures and more recitations and discussions. To narrate to a class facts which the pupils can easily glean from accessible books may be good exercise for the teacher, but I am certain that it is equally deadening to the students. It is important, therefore, that the pupils early cultivate the habit of consulting standard works on the subject; the habit of asking themselves and the books rather than the teacher the answers to their questions. Practically every school has at least a few books for reference and fortunately the pupils are learning to use them more and more. In some cases they are not used simply because the pupils are unfamiliar with them or do not know how to use them. Sufficient time should be taken at the beginning of each course to convince one's self that the pupils are familiar with such books as are accessible. They should know the kind of information to be obtained from the various books and should be trained in the use of them.

The ideal text-book is, I am sure, one that has not yet appeared and it is safe to say that it never will. True, a large number of texts in elementary chemistry have been written, and every year adds to the list. For one I rejoice that this is the case. I have no sympathy whatever with the sentiments so often expressed or plainly implied that it is little short of a crime to add to the list of texts already published. In some cases the author himself in the preface almost apologizes for writing the book, while not infrequently the reviewers strongly imply that it requires a great deal of audacity to add to the number. I read a review recently that in substance was about as follows: "My goodness sakes alive, here is another text-book in elementary chemistry! Who has had the audacity to do such a thing?" Whereupon the reviewer proceeded to behead the author in a way that would have done justice to the French revolutionists. Such views as these are certainly all wrong and in direct opposition to the scientific spirit—the spirit which welcomes all honest effort and culls from it whatever of good there may be. I believe that

no text-book was ever written that did not result in good to some one, even if only as an exercise for the author. I have never yet closely examined any text, however, in which I was not able to find something praiseworthy; in the great majority of cases something that I could use in my classes, something that was of direct benefit to me. True, in a few cases the extent of the commendable features was, to my mind, very limited. * * *

Coming now to the subject proper, it seems to me that entirely too little attention is paid to what may be called the mechanical side of the book. Verily a good binding, good paper, good printing and good cuts cover a multitude of sins. All of this is not attributable to the author; the publisher must take his share of praise or blame. It is certainly not always a case of expense, but rather of good taste. The ornamentation that occasionally decorates the binding of books is sufficient to condemn them forever in the eyes of the student who has any sense of what is appropriate. The binding, the paper, the cuts, the printing, in short the general appearance of the book—these are what first strike the eye and any unfavorable impressions made are not easily offset by other good qualities.

In the next place it seems to me that the text should be concise and embrace only as much of the subject as can be mastered in the ordinary time allotted to the course. I know that many of you do not agree with me in this opinion. For example I was recently told by a prominent teacher that he always used a text that embodied far more of the subject than the student could master for the reason that he wished to be assured that the student would not get the impression that he had learned all that is known of the subject. For myself, however, I vastly prefer as a text for elementary students one that can be thoroughly studied, reviewed and re-reviewed if necessary, and upon which a searching final examination can be given covering the entire course, to one that is so extended that the student must omit page after page of it or else do the work in a very superficial way. If only portions of the book are to be studied then that treatise becomes more of a reference book and as such should be accessible to the student. I must confess, therefore, that I look-

with disfavor upon the growing tendency to increase the extent of the subject-matter in the texts for secondary schools. I have always supposed that the time was past, if indeed it ever existed, when a teacher was judged by the size of the text used in his classes. I was told recently, however, by a representative of one of our prominent publishing firms that with few exceptions schools of inferior standing and equipment always use a large and very complete text-book, in order to impress you with the magnitude of the work they are doing.

Again, I believe that above all the text should be a practical one— a "workable" one. By this I mean that it should be adapted strictly to the needs of the student. The experiments intended for the pupil should be such as can be performed by the pupil. The apparatus described should be as simple as possible and should be such as is available in the average school. To illustrate my meaning, I don't know of any form of hydrogen generator that is more troublesome in the hands of the pupil than a round bottom flask, nor one more practical than an ordinary wide-mouth bottle. Yet you will be surprised in the examination of different texts to find how many picture the former and how few the latter. I am quite sure that in general there is room for vast improvement in the selection of cuts. Indeed, it seems that often certain forms of apparatus are represented simply because it proved easier to make the drawings for them rather than the forms that are best adapted for use. Sometimes the cuts border on the ridiculous. The following review of a recent text may be somewhat overdrawn but I take it from one of our standard journals: "The pictures are reproduced from photographs and show three tiers of apparatus arranged as if for sale. In many cases it is not easy for an experienced chemist to recognize the individual pieces, and in plate XX we reach a climax. It represents on the top shelf two tin canisters, a stoppered bottle, a Bunsen burner, a beaker, a tin dish, a blowpipe and another stoppered bottle. On the next shelf are three stoppered bottles, a hammer, four tin canisters, a small structure like a dog kennel, and a rack of twelve test tubes. On the bottom shelf are two developing trays, a beaker, a stoppered bottle, a sugar basin, a stone ginger beer bottle, a pocket handkerchief, and apparently a bank note or a shirt cuff."

In some recent texts the ordinary drawings are largely replaced by photographs. This, perhaps, adds to the artistic side of the book, but I am inclined to believe that the arrangement of the various tubes and their connections can best be shown by ordinary cross-sectional drawings.

Similarly, let me illustrate what seems to me examples of the impractical selection of chemicals. In a well known text I find that the pupil is instructed to burn some calcium and compare the oxide formed with ordinary lime. This would no doubt be an exceedingly interesting experiment. I note, however, that in Eimer and Amend's catalogue calcium is quoted at $12.50 per gram. This is again an exaggerated case, but it is not hard to find many others of a similar nature. I find, for example, in a book which has just been published, the instruction to the pupil to introduce a few grams of the white powder phosphorus pentoxide into a beaker and expose to the air, illustrating deliquescence. The expression "a few grams" is a most convenient one for the writer, but I am not sure that it has a place in the elementary text. Just how many grams are a few grams? I recently asked the different members of a class the answer to this question. Naturally, I found a wide difference of opinion. They finally agreed that about five grams would be the proper amount. Now, any one who has worked with phosphorus pentoxide knows that it is a very light, bulky substance, and that five grams of it would fill a small beaker; and to instruct the pupil to use such an amount as this in order to show that it will attract moisture is cultivating in the student the unfortunate habit of using excessive amounts—a tendency which must be fought rather than encouraged.

Again, the experiment chosen should be as simple as possible, consistent, of course, with good results. I never could understand why the pupil should be directed, as he so often is, to burn a piece of magnesium wire as an illustration of a chemical change. Just what advantage has this over the combustion of a match or an ordinary splint? To be sure, the combustion of the magnesium is attended by more "fire works." But this is only another reason why the experiment should be condemned. The student is so awe-stricken and overcome by the brilliant light that he is likely to for-

get what the experiment is to illustrate. Moreover, illustrations should be chosen whenever possible from the realm of the familiar.

Naturally, we find such errors of judgment, if I may so call them, largely in books whose authors have had little or no experience in teaching elementary chemistry to such pupils as we find in our secondary schools. To teach elementary chemistry to sophomores or juniors in a college is quite a different proposition from teaching it to students in secondary schools, and many contentions have arisen from a failure to recognize this very obvious fact. In order to write a "workable" text it is absolutely essential that the author be able to transform himself, so to speak, into the pupil for whom the text is intended and to study the book from the pupil's standpoint. Therefore, it is only the individual who is intimately acquainted with the limitations as well as possibilities of the pupil in the secondary school who will succeed in writing a "workable" text. Mere knowledge of chemistry is by no means the only requisite of the successful author. Occasionally we find a man preëminent as an investigator, but without experience in dealing with the practical problems that confront the teacher, undertaking to write an elementary text. One of the most recently published texts in elementary chemistry is by Professor Jones, of Johns Hopkins University. Professor Jones is, I believe, generally recognized as one of our most prominent physical chemists, and his researches have added materially to the advancement of physical chemistry. His book has many excellent features. While I have no information upon the subject, I will venture the conjecture that Professor Jones has never taught chemistry to pupils in secondary schools, for in no other way can I account for many of his statements and methods. For example, his experiments seem to me to be particularly impractical ones for students. Let me refer to a single one, one that has for its object the quantitative synthesis of water. The directions are very brief, since the pupil is supposed to get the information largely from the accompanying drawing. The hydrogen generator is represented as a bottle of such proportions that I am sure the average pupil would not be satisfied with one holding less than three or four liters. Two bottles, proportionally large, are represented as half filled with a liquid and connected, one at each

end of the tube containing the copper oxide. According to the description, the liquid in the first bottle is sulphuric acid; but no mention is made of the second bottle or its contents. Perhaps the author thought that any pupil ought to know that it, too, is to be filled with sulphuric acid. The assumption of the possession of such knowledge by the pupil is, however, entirely unwarranted if my experience counts for anything. The pupil is directed to "weigh the amount of copper oxide used and weigh the mixture of copper and copper oxide after the experiment is completed. Weigh the cylinder containing concentrated sulphuric acid before the experiment and weigh the cylinder and water after the experiment." Since the first cylinder is the only one described, if the instructions were strictly carried out, the pupil would weigh this one. Any experienced teacher could easily tell from the directions that the experiment would prove a total failure. It belongs to the class of experiments that, judging from directions, look so easy that it is hardly worth while to perform them; but as a matter of fact they are beyond the skill of the average pupil and not infrequently, I fear, will fail to give consistent results even in the hands of the most skillful teachers. Note the amount of materials used in some of the other experiments described. Oxygen is prepared by heating a mixture of twenty-five grams of potassium chlorate and a like amount of manganese dioxide, introduced into a non-tubulated retort. The combustion of sulphur is shown by introducing it into a bottle containing three liters of oxygen. The watch-spring is burned in a bottle holding three or four liters, while phosphorus is burned in a wide-mouth vessel containing several liters of oxygen. One would naturally imagine that these directions apply to experiments to be performed by the teacher only. So far as one can judge from the preface, however, they are to be performed by the pupil.

Of course, the book should be accurate in its statements. It must be confessed, however, that very few, if any, books are entirely free from inaccuracies, since even teachers and chemists are human beings. The results of modern research have shown that many of the common statements made in the texts and generally accepted are not true in the strict sense of the term. Such

statements, for example, that hydrogen and oxygen will not combine at ordinary temperatures, that water when decomposed by the electric current yields only hydrogen and oxygen, and that the volume of the former is exactly twice that of the latter, are certainly not true. Whether such statements are admissable, however, may be a question for argument. In reference to other statements with which one often meets, however, there can be no question.

It not infrequently happens that the same error is handed down from one generation of books to another. This accounts for the fact that it is almost impossible to keep out of texts a false statement if once printed in a reputable book. For an illustration we may refer to the statements made concerning the composition of natural gas. All the evidence goes to show that not more than a small amount of free hydrogen exists in natural gas—at least in the natural gas of today; indeed, those who have done most work on the subject and whose opinions are entitled to the weightiest consideration have failed to find even a trace of free hydrogen. Attention has been called to this fact repeatedly, but the statement continues to be included in many of our texts. As recent a work as that of Clark and Dennis' includes the statement that natural gas contains from 10 per cent to 36 per cent of free hydrogen. Since this statement is so often made it may be of some interest to trace the origin of it. The first extended analyses of natural gas were made by Mr. S. A. Ford, chief chemist to the Edgar Thompson Steel Works in Pittsburg. These were reported by Mr. Carnegie in an address given before the Steel Institute of Great Britain, May 8, 1885. The address was published and the analyses were copied widely, being the first made of a substance that was attracting great attention. Mr. Ford's analyses showed natural gas to be a most remarkable substance, since when taken from the same source on different days it showed no tendency to maintain such a constant composition as one would expect in a gas obtained from the same source. Thus, samples taken from the same well on different days showed a variation from 9.46 per cent to 35.92 per cent of free hydrogen. This variation was noted and was the subject of some comment. Thus, Orton, in Volume VI of the Ohio Geological

Survey, calls attention to this feature of the analysis and adds that such variation would be expected to produce more irregularity in use than has been reported. Later it was shown that the gas from a number of different wells in Ohio and Indiana was uniform in composition and showed no tendency to the lack of constancy disclosed by Ford's analyses. Finally, Professor Phillips took up the subject and showed with great exactness that the gas from the Pittsburg field did not contain even a trace of free hydrogen. It is very difficult to interpret Mr. Ford's results since no reasonable explanation has been offered to account either for the great variability in composition of the gas or the very striking changes in composition that must have taken place before the work of Phillips was carried out. In the light of these facts many have refused to accept the analyses of Mr. Ford. Thus, Orton, in the report referred to above, states "that on page 135 the analyses of the Pittsburg gas made by Mr. S. A. Ford are given and discussed. The remarkable character of the analyses was noted but not questioned. It was supposed that so anomalous and surprising results would not have been published unless they had been established beyond all question. This conclusion has proven to have been a mistaken one."

I have been surprised also to find to what extent different texts disagree in reference to data about which there ought to be no question. For example let us take the question of the ignition temperature of oxygen and hydrogen. Newth states that a mixture of hydrogen and oxygen (electrolytic gas) explodes at 612°, giving as his authority Victor Meyer. Holleman says that the temperature is about 700°. Jones, in his Principles of Inorganic Chemistry, states that if the two gases are perfectly dry the mixture may be heated above 700°, which, he adds, is far above the ignition temperature, without the slightest combination taking place. Hessler and Smith state that hydrogen and oxygen unite with great violence at about 350°. Such variations as the above would not lead one to believe that chemistry is an exact science. My attention has been repeatedly called to the fact that the statements made in many of the elementary texts in reference to the distinction between wrought iron, cast iron and steel convey at most only a partial truth. Thus I quote from

Dr. Newell's text: "Steel is intermediate between cast iron and wrought iron as far as its proportion of carbon is concerned." This, of course, is not always true. In fact the difference between wrought iron and steel is today as much a difference in method of manufacture as in ultimate chemical composition.

The extent to which theory should be included in an elementary text has been a matter of much discussion and I presume we are all agreed that no reference to theory should be made until the student clearly recognizes the necessity for it and then only so much should be included as will serve to properly explain the facts and phenomena embodied in the text. I was interested in reading a recent article by Benedict, published in SCIENCE, in which he takes the ground that it might be well to eliminate theory entirely from the elementary course in secondary schools, substituting for it a more extended discussion of the applications of chemistry to daily life, such as is included in Lassar Cohn's "Chemistry in Daily Life."

Of course such a view is a very extreme one, and I doubt if it would find any advocates in this assembly. If we had to adopt extremes, however, I believe that I would rather adopt that advocated by Professor Benedict than the opposite one, viz.: that the elementary course should consist largely of theoretical discussions without reference to the applications of science. The reason why theory should be as largely eliminated as possible from the elementary course consistent with an intelligent discussion of the subjects included is not because the theory is unimportant, but because at this stage of development the pupil seems unable to appreciate the value and importance of the theory in connection with the subject. I believe, therefore, that the text should preface the theoretical discussions with a far more extended discussion than is generally given upon the value and the absolute necessity of theories in connection with the development of the science. I am sure that the teacher should satisfy himself that the pupil has a clear understanding of the true value of theories and their relation to laws and facts before the general theories are discussed. It was always my custom to preface the study of a theory with a general discussion of its importance, assigning the

topic some days ahead of time in order that the pupils might have an opportunity for a study of the question. The various opinions offered on these occasions would convince the most skeptical that at this stage of development the average pupil has no definite idea of the part that theory plays in the growth of a science and that he is apparently unable to distinguish clearly between theory and fact. For example I find that the pupils using Remsen's text (Introduction to the Study of Chemistry) are very prone to regard the laws of definite and multiple proportions as a part of Dalton's theory, simply because they happen to be included in the chapter with it.

I presume that we are also agreed that the text should contain some reference to the applications of chemistry to daily life. The science has a new interest to the pupil when he recognizes that a knowledge of it is of practical value and that its applications are closely connected with our material advancement. It does not seem to me, however, that such applications should be treated in detail. The elementary text is certainly not a treatise on mechanics or industrial chemistry any more than it is a treatise on qualitative analysis. The principles involved in the applications, however, may be discussed and in some cases the method of application illustrated by simple diagrams, although care should be taken not to enter into detail. For example Dr. Newell's Descriptive Chemistry, published during the present year contains, in addition to a full-page cut, something over two pages of finely printed matter descriptive of the method of manufacturing coal gas, almost as much as you will find in some of the treatises on Industrial Chemistry. I can not help thinking that this is a serious mistake. The pupil is almost sure to be so overcome by the array of "retorts," "stacks," "benches," "hydraulic mains," "tar wells," "condensers," "exhausters," "scrubbers," "tar extractors," "purifiers," "meters" and "holders" (which names I take from the text) that he loses the important part of the subject, viz., a simple study of the chemical principles involved.

I have noticed with a good deal of interest the growing tendency on the part of the authors of elementary texts to conclude the different chapters with a series of questions or exercises. In

some cases these are of such a character as to necessitate independent thought on the part of the pupil, the answers to the questions not being directly found in the book. In others, however, are included questions on the matter contained in the chapter. Thus in Dr. Newell's book referred to above we find at the end of the chapter on oxygen a series of questions the first three, for example, being as follows: "What is the symbol of oxygen? How is oxygen prepared (a) in the laboratory, (b) commercially. Name several compounds from which oxygen can be prepared." The answers to these may, of course, be found in the chapter. Now I wonder if all this is in accord with modern methods of teaching and whether it would be sanctioned by those who are most competent to judge. The growing tendency to include the questions seems to indicate that the method is a popular one with the teachers. I believe that the pupil is often able to master more thoroughly the contents of a chapter when provided, and hence guided, with a proper list of questions. He seems unable to select the important parts of the discussion. If furnished with a list of questions, however, he has something definite to work upon. I have often resorted to this method, especially when the subjects under discussion were difficult, but I have always felt that I was doing an injustice to the pupil, that I was cultivating bad habits, feeding him on at least partially pre-digested food and laying up trouble for him in the future; that it was very essential that the pupil should learn to select for himself and master the important principles without having them pointed out by a series of questions. I fear that the average pupil is already much too dependent on questions. Ask one to discuss the properties of oxygen and as a rule he will omit half of them. On the other hand if you ask him a large number of questions in reference to the properties, the questions themselves suggest the various parts of the subject and he is able to answer them. There is no doubt but that the printing of such questions in the text makes it easier for the teacher for he is spared even the mental effort necessary for the framing of the question. There is no doubt, either, but that the method conduces to good recitations; so I would be glad if some one present would convince me that the system is sound pedagogically.

The text must not be radical in its treatment. The author must be a fair-minded individual who has some consideration for the opinions of others. Changes in the method of teaching elementary chemistry belong just as much to the process of evolution as changes in life itself. Even if our methods are entirely wrong they can not be corrected in a day and the author who attempts to do it is sure to fail. It is not uncommon for a text-book in elementary chemistry to appear which presents an entirely new method in the treatment of the subject. Many of these books have much to be said in their favor. Some of them are scholarly productions and are highly praised in the reviews. But it is certain that no one of these has as yet presented a method of treatment better adapted to the needs of the great majority of our schools than that now in general use.

Among the departures from the prevailing methods must be included those treatises in which the author would have the student discover everything for himself—the so-called heuristic method. Without entering into a discussion of the advantages of this method, it is certain to fail in the vast majority of our schools. For example it is very essential that the boy who expects to be an engineer shall know something more about chemistry after having studied it a year than he is able to discover for himself. Moreover if the method is a proper one for chemistry, it certainly ought to be the proper one for the natural sciences in general; and this would require a complete change in our educational system.

We hear a great deal of discussion at the present time as to whether the theory of electrolytic dissociation should be included in our elementary texts, and if so, to what extent. Most authors have been forced to recognize its value. The method of doing this is not always a logical one. Some have simply admitted it into the preface, while others have satisfied their consciences by an occasional use of the word "ion." In all cases, however, there is plainly evident the feeling that as authors of elementary texts they are sorry that the child was ever born. We have at least one elementary text arranged for secondary schools which in its preface purports to be written from the standpoint

of the theory of electrolytic dissociation, viz., Jones' "Elements of Inorganic Chemistry." In his preface he asks, "Why continue to teach chemistry from a purely atomic standpoint when it has been shown not to be in accord with the facts?" and adds "the only answer is that perhaps it is a little simpler." The author, however, who attempts to write a perfectly consistent elementary text based on the chemistry of ions will have no easy task. Dr. Jones is certainly not consistent. The reactions are largely written in the way he denounces as untrue, although occasionally he recalls that statement in his preface and adds one written "ionically," if I may be allowed the word. Dr. Jones' statement that we are clinging to worn out theories simply because they are easier to present, if true, is certainly one which demands consideration. I believe, however, that it is, to use a chemical phrase, a little concentrated and might bear considerable dilution. Any theory which best enables us to explain the facts and phenomena treated of in the text ought certainly to be included, provided, of course, that it is not beyond the intelligence of the pupils for whom the text is intended. The author has no other alternative than to use it as a basis of explanation. It must be remembered, however, that the theory of Electrolytic Dissociation is still the subject of many severe criticisms. It has not been long since I read an article in School Science (you will recall it, I am sure) in which one of the most prominent professors of physical chemistry in this country denounced the whole theory as absurd and advised teachers of chemistry to have none of it. While it is undoubtedly true, however, that some of its admirers have pushed it too far, I do not understand how anyone can doubt that it contains the elements of truth and that no matter how many facts may be urged against it, it is here to stay until a better one is advanced.

And now in conclusion I wish to say that I recognize that I have given no patent method that will enable one to produce an elementary text. I have simply discussed what I believe to be some of the requisites of a text adapted to our secondary schools. In the discussion I have had occasion, by way of illustration, to criticise certain statements made in some texts. I

certainly hope that I have not conveyed the impression that I see naught but imperfections and wish you to recall what I said at the beginning of the discussion, that I have never closely examined a text in which I could not find something praiseworthy. There are most certainly a number of excellent texts in chemistry written by men eminent as chemists and teachers. To say, however, that these texts could not be improved upon would be to say that we have reached perfection. That present texts will be improved upon and that new and better ones will appear as our knowledge and experience grows, no one will gainsay. I trust that the members of this Association may have a hand in this important work.

IS THE BIOLOGY COURSE FOR COLLEGE ENTRANCE REQUIREMENT BEST FOR THOSE WHO GO NO FURTHER?*

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In discussing the topic assigned for this series of discussions it seems to me that we must consider the following questions: Will the largest general good result from a course of study planned for the purpose of giving the maximum of scientific training? Or from a course that will give the largest possible information regarding things to be encountered in later life? Or from a course planned to include full recognition of both these points of view? Or are the needs of the two groups of students such that it is best to have two courses, one for students not going to college, and another for those who are? It is assumed that all recognize that the so-called disciplinary course must include some of the informational element, and that discipline can not be absent from an informational, industrial or technical course. This is a question of proportion and not of content.

*Address before the Biology Section of the Central Association of Science and Mathematics Teachers at a meeting held in Chicago, November 27, 1903.

The answers that have been given to these questions may be found in the form of those courses in biology that have the sanction of the best teachers of the subject. While there are many variations in the courses given, there is essential agreement among the best ones. Primarily they agree that for any very serious presentation biology must be divided into a course in zoology and one in botany. While I shall speak mainly of the course in botany I must say that I see no reason why the things said of botany are not equally applicable to zoology.

Those who have formulated the most effective courses agree that each student should understand that all plant structures and activities that he studies are related in some way to the problem of nutrition, or that of reproduction, or to both of them. As early as possible in his course he should appreciate the fact that plant work is the thing for which organs, tissues, and bodies exist, and his subsequent study should be done in the light of this fact. Not only the nature of the mind of the student but the nature of the subject with which we deal demands that in any general course we see the activities of plants, and that organs are the things through which these activities are expressed. Knowledge of these organs, their peculiarities, and their names is essential in order that we may make intelligent statements concerning the work done. Any study of the organs or the tissues alone, morphology and anatomy, unrelated to physiology does not represent a general course in botany but a special one. And the same thing is to be said of the study of ecology that leaves out of account the fundamental notions of morphology. Our students can not study functions apart from structures and they must not be forced to attempt to study structures apart from functions. We are no longer in much danger of the latter possibility but we seem to be in increasing danger of attempts at the former.

Those who advocate a course such as that I have suggested believe that since the activities of plants can be interpreted only in connection with a study of structures, morphology should form the basis of organization of the course of study. These morphological considerations have something to do with determining what topics shall be taken up, but have much more to do with determining the order in which they shall be considered.

Two possible courses of procedure based upon the plan just suggested, find application in various parts of the country, and both are accepted by the colleges. One begins with a consideration of seed plants and toward the close of the course takes a brief survey of lower groups. The other, after having worked with seed plants enough to establish a notion of nutrition and reproduction, and a general idea as to how structures are related to these, then procedes to consider plants from the point of view of the order in which they develop. While having the disadvantage of necessitating the use of unfamiliar tools, in this second plan there is the greater advantage of being able to observe simplest forms that do their work in simplest ways and to see, in a way full of interest to all, the gradual transitions to plants that are in a constantly increasing degree able to do their work in better ways. That some of the most interesting and most important things in plant life may be presented in such a course is made evident through the possibility of discovering in process of the work the solutions of such questions as the following: "In comparing *Oedogonium* and *Spirogyra* what is the significance of *Oedogonium's* holdfast?" "How does the branching habit of *Cladophora* better fit it for its work than does the unbranched habit of *Ulothrix?*" "What is the significance of the form of plant body of the moss as compared with that of *Marchantia?*" "In the fungi what results have followed the adoption of the dependent habit?" "By comparing a pine and a lily show the differences in structure involved in the differences between the evergreen and deciduous habit of living." These and many more such questions arise from the logical development of this course. Such a course if well presented leaves the student with a knowledge of the plant kingdom as a unit, with some knowledge of the leading groups that compose the plant kingdom, with a knowledge of the leading processes of nutrition and reproduction, and of the adaptations that are made throughout the groups as plants under various surroundings adjust themselves to these pieces of work. Associated with these things, to the best students there will come some general knowledge of the evolution of plants.

This course, or any one representing the same sort of work, would no doubt be most gladly accepted as an entrance require-

ment by the department of botany in any of our colleges. In my own work I should be happy to find that such a course is common to those students from the high school who present themselves for entrance. An occasional sample is quite satisfactory, but the supply is such that the high school has not yet been able to fill a large order. This may stand, however, as a type of those courses that the higher schools are willing to accept as an entrance requirement. It should be said in this connection that most colleges are far more liberal than the outline above would indicate.

But the question has been raised numerous times as to what is the practical value of such a course, and as to whether this is not a sort of college-made mold into which we propose to fit all students regardless of whether they are to go to college. As to the practical values, I believe such a course is full of them, though they are not always of the sort most readily recognized by the parents of the boys and girls. The parent says: "My boy can not go to college. How can such a course in botany or zoology help him in living?"

It is an easy matter to wake a whole community to a financial advantage or to a question of ethical content, but by no means easy to find appreciation for a matter of intellectual content, though as a matter of fact, the intellectual side of science goes to the very basis of money and morals.

The method of thinking developed in a good course in botany or zoology is essential to the highest success in any line of work. The ability to observe phenomena, to gather data, to form hypotheses, to reject them and form new ones, to come to conclusions that are based on considerable evidence, to be open to contradictory evidence, to desire to know what is true rather than who is right; these things have a distinctly practical value in the lifework of each boy and girl though they may never see the walls of a college building. One has but to look at the things being put forth as opinions that are nothing more than whims and prejudices to cause him fervently to hope that the true method of science may become the possession of all the people all the time. This method is relatively young in education and has not become

transferred to the reflex systems of any of us. Those who in their own fields know the method best, often get into unfamiliar fields where they think according to unfamiliar methods.

People are not suffering so much from poverty or bad ethical conditions directly as they are from poor intellectual life. Says one of our foremost biologists, "We are oppressed not because of the strength of the strong, but because of the weakness of the weak." Many of the ills of the common people could have been averted had there been a little power in seeing phenomena and in properly deducing conclusions therefrom. It is part of the business and is the privilege of biology to help develop a reasonableness of mind that shall raise the intellectual life of the common people and thereby affect their economic and ethical life.

As suggested above it is most difficult to get people to see the need of better thinking unless that thinking is definitely applied to some specific thing that soon brings a financial return. Parents are reasonably alert in insisting that their children be protected against financial loss either in fact or in opportunity; somewhat alert with reference to physical injuries; a few of them are actively anxious concerning ethical progress; but only a very few are actively anxious concerning intellectual progress. As they come into a fuller recognition of the high importance of good thinking science will come into her own. Karl Pearson says: "There is no short cut to truth, no way to gain a knowledge of the universe except through the gateway of scientific method. The hard and stony path of classifying facts and reasoning upon them is the only way to ascertain truth. It is the reason and not the imagination which must ultimately be appealed to." And it is just these things that are to give us industrial and ethical safety.

Another highly practical value that must come from a good botany course as well as from other science courses is ethical. A knowledge of the law of causation is fundamental to good ethical life. There is no result without cause. Dependency is followed by degeneracy. Dry land conditions produce dry land results, not always the same, but of a class similar. As conditions change, as they are always doing, organisms must accept one of three prop-

ositions; migrate to new conditions essentially similar to the old previous to the change, remain within changing conditions and readjust and readopt so that prosperity may be had, or refuse the first, and the second, and die. This has an ethical content of no mean value, and is full of significance to young people. From the above, as seen through various illustrations in the plant and animal kingdoms, it is evident to young people that life must of necessity be one of constant growth and advancing adjustment; one of migration or of failure.

In this connection it must be said, however, that any attempt to make a course in botany purely an ethical one would result disastrously to botany. The ethical values in the main are those which "When ye would have, ye have not, and when ye would not have, ye receive." But they are so important that in summing our values from our course they should not be omitted.

The information that is obtained is more likely to appeal to many as the most important result. When such a course as outlined has been followed, the student has a definite knowledge of many individual plants, their ways of living, their homes, and the large groups to which they belong. No course should fail to give an outdoor speaking acquaintance with plants, thereby enlarging the general interest and pleasures of the student. Few people are entirely devoid of the pleasure of knowing things just for the sake of the knowing, but much of the knowledge of plants is directly useful.

To the best students there will come some knowledge of the significance of the ideas involved in organic evolution. This knowledge will not be detailed, but will grow out logically from the consideration of numerous phases of the course. This will initiate the student into a point of view that will prove helpful to him throughout his life.

A more directly practical result will be found in a knowledge of economic botany. In connection with algae, fungi, gymnosperms and angiosperms it is easy for the student to obtain some notions as to the uses man has made of plants. Sources of plant products used in the industries and as food should receive brief mention in a general course, and will be found of much interest

and lasting practical value. In connection with the study of fungi in addition to a knowledge of different forms of dependency, some valuable knowledge is obtained as to the economic aspects of many of the parasitic forms. The special field of bacteriology into which the general course can not venture very far, should receive enough attention to leave the student with a general knowledge of causation and prevention of disease as we now understand those things.

The second question as to whether this is not a sort of college mold into which we propose to fit all students regardless of whether they expect to go to college, seems to me easily answered. The college has little to do with the matter except as the college is anxious to see the best thing done for the largest number in the high school. There have been occasional cases, doubtless, where college instructors desired the high school to teach those things that look toward further work in college in some particular line. But these cases are exceptional. I believe nearly all the colleges desire, not that certain high school students shall be favored in order that they may be more proficient in taking up special work in college, but rather do they desire to see all high school work better done, knowing that all are benefited thereby and thus they obtain better entering students than would otherwise be true.

It is natural that in botany certain universities and colleges insist upon certain things as essentials in the high school course. They hold a point of view represented by those things in their own work, and we do not believe they would do so did they not think that these best represent the subject. There must be some difference in the recommendations made by different higher schools, since in their own work they do not emphasize the same things. Their recommendations are sometimes made wide of the mark because of lack of knowledge of the conditions existing in the high schools. The man who based his general course for beginners on cytology was doubtless a good cytologist, but did not properly diagnose the case in hand.

I believe the colleges are fairly well agreed that whatever is best for the high school boys and girls is best for the college

to accept as an entrance requirement, and the fact that they will accept anything that is at all like a good course in botany is ample evidence as to their position. High school courses do not exist for the purpose of preparing students for special courses in college. Whenever they do so prepare them and at the same time do the best for the larger number who are not to go to college such is highly desirable. In no sense should the high school be a college preparatory school, except as such is corollary to the more fundamental work of the high school.

The prospective college student is to have another opportunity in college. If he does not get a good course in botany in the high school he may elect botany in college and retrieve his losses. But there must be a good course for the other boy, a course that represents botany, that gives him the far-reaching benefits of such a study, that teaches him about plants, where and how they live and the uses man may make of them, but above all a course so logically organized and definite in its discipline that he may be helped toward such thinking that he may become a reasonable creature, guarded against intellectual and ethical pitfalls because he has scientific insight and power. The question is not "Is the course good enough for the boy and girl who are to go to college?" It is "Is it good enough for the boy and girl who can not go to college?"

THE PEDAGOGICAL BEARING OF CHEMISTRY ON PHYSICS.*

BY ARTHUR JOHN HOPKINS,

Associate Professor of Chemistry, Amherst College, Amherst, Mass.

Physics and chemistry are sister sciences. In the early decades of the nineteenth century they were studied together, and, in many instances, taught together. In fact, no distinction was possible between these subjects until heat and light were recog-

* A paper read before the Physics Club of New York City.

nized as forms of energy rather than material, and the real elements were found underlying the four so-called elements of the Greek philosophers. All this was accomplished before 1805; from about that date our sciences began their separate existences. It was not, however, until the middle of the last century that sharp distinctions arose, because then the development of the quantitative side of each subject began to change what had been merely descriptive into exact sciences. Physics, with its forces and motions and wave-lengths is, at the present time, allying itself more and more with pure mathematics; chemistry with the dead materials of the universe. To the physicist with his pure abstractions, the "touch-and-feel" of the chemist is a mystery—a curious way of looking at things.

Each science has its methods peculiar to itself and, to some extent, unadapted to the other, yet there are in each ways and methods of presentation, of mutual pedagogical value.

It is important to recognize these differences in our two sister sciences and for the teachers in each subject to learn and profit by the knowledge of those points in which superiority is claimed.

It is not my purpose to direct your attention to the advantage which a teacher of physics may gain by knowing the *subject* or the facts of chemistry, for although chemistry is the science nearest allied to physics, truth spoken on this relationship descends to truism; for every science teacher is a better teacher of his subject the more science he knows and these arguments gain not in kind but only in strength the more closely the sciences discussed are allied. My argument, therefore, will not relate to the subject-matter of chemistry neither will it relate to the more specialized branches of qualitative and quantitative analysis, which are of great pedagogical value in the chemistry course; but will direct the attention of physics teachers to a knowledge of the best methods in current use in the so-called *"Course in General Chemistry."*

I come before you, therefore, to claim that since the separation of chemistry from physics (the methods of teaching chemistry having advanced to a higher plane than before that separa-

tion) chemistry now finds itself in point of pedagogical methods superior to its sister subject.

Two arguments present themselves to us in support of this claim. They may be placed under the following heads:

First—Simplicity in the method of presenting the subject in class.

Second—Unification of the laboratory instruction.

I.

In a paper read by Professor Franklin before the American Physical Society in this city on October 31, you will remember a distinction was made between systematic physics and statistical physics. Statistical physics includes those portions which describe phenomena, more or less erratic and in which the notion of cause and effect fails. So far as laws like those of mechanics and thermodynamics are applicable, so far is our physics systematized—or in other words, so far can the subject of physics be presented as a scientifically coördinated whole. How much of such coördination is apparent to the *pupil,* while he is conducted rapidly from mechanics through the usual sub-topics of sound, heat, electricity and light, it would not be seemly for the chemist to question.

Turning quickly now from physics with its many topics and descriptions, more or less coördinated, to the subject of chemistry as it is sometimes and, I am ashamed to say, too often presented, we have here nearly seventy distinct topics, the seventy elements, each with its individual description, and of each element a multitude of compounds each with its separate description. With such chemistry let us have nothing whatever to do. Whether this be known as descriptive chemistry or chemistry non-descript, it has been relegated long ago to the teacher who would have his pupils believe that chemistry is easy, if their memorizing power is good.

When general chemistry is properly taught it presents to the pupil, almost from the beginning and to the very end, with all its variety, with all its multitude of compounds, only two main subjects—*bases* and *acids*—or, in the language of physical chemistry, the two classes of elements which in solution produce hydro-

gen or hydroxyl ions. About these two opposite but related classes the whole course revolves. The student early learns that his powers must be bent to understand not the elements as individuals but as classified into base-forming and acid-forming elements. The teacher's whole labor is to present acids and bases so that they will be understood simply at first, and then so that he may gradually lead the pupil to include under these two topics, or as closely related to them, all the important branches of his subject.

Let me illustrate the chemist's progressive method of presenting his subject from the way in which the idea of an acid, and the idea of the acid-condition and relationship, should gradually sweep aside all minor considerations in the pupil's mind.

Under that early subject, *"The Occurrence of Hydrogen,"* we find our first definition of an acid. Relating simply to the composition, the definition reads that an acid contains hydrogen and (it may be) that the hydrogen is united with a non-metallic element or group. At that stage of instruction this simple working definition is sufficient. More would be an enormity. What though the definition be untrue? The instruction, it is to be remembered, demands *simplicity* and *progression*—not truth.

Immediate progress comes when the subject of chlorine is begun—usually the very next element. The compound hydrogen chloride (hydrochloric acid gas) is studied and it is found that this substance is inert when dry but active in solution. We learn from this first illustration of an acid that the water is important to the acid condition. The notion of hydrogen ions is perhaps introduced and opposite notions regarding bases. Later under ammonia gas the compounds containing hydrogen, non-dissociated in solution and therefore not acidic, give us illustration of the bounding idea of an acid—not only what an acid is but what it is not. Here also we may return to our original kindergarten definition regarding the composition of an acid, by showing that a sufficient increase of the non-metallic properties in a basic group may produce an acid, by showing that the oxidation of ammonia or ammonium hydroxide carries us over to nitric acid.

Not yet have we finished with our delineation of the acid relationship, for when we reach metals, as one metallic element after

another is taken up, as we pass in the usual order through potassium, sodium, calcium, zinc and aluminum, we find the decline in base-forming properties is marked by an increase in acid-forming properties, for aluminum hydroxide is either a base or an acid, depending upon what it is used with and the chain of properties is completed between the bases and acids.

I have omitted all discussion of oxides and anhydrides, in which it is shown that the oxide of a metal with water produces a base, thus $CaO + H_2O = Ca\ (OH)_2$, and that the oxide of a non-metal with water produces an acid, thus: $H_2O + CO_2 = H_2CO_3$; of acidic and basic salts, of acidity and alkalinity and the beautiful illustrations in organic chemistry which may be brought out between these two great distinct but interlocking classes of chemical compounds.

Thus:

$$N\left\{\begin{matrix} H \\ H \\ H \\ H \\ OH \end{matrix}\right. \longrightarrow N\left\{\begin{matrix} O \\ O \\ OH \end{matrix}\right.$$

Which is easily shown by the following equations:

$$(1)\quad Al\left\{\begin{matrix} OH \\ OH \\ OH \end{matrix}\right. + \begin{matrix} HCl \\ HCl \\ HCl \end{matrix} = Al\left\{\begin{matrix} Cl \\ Cl \\ Cl \end{matrix}\right. + 3\ HOH.$$

$$(2)\quad \begin{matrix} NaOH \\ NaOH \\ NaOH \end{matrix} + \left.\begin{matrix} HO \\ HO \\ HO \end{matrix}\right\}Al = \left.\begin{matrix} NaO \\ NaO \\ NaO \end{matrix}\right\}Al + 3\ HOH.$$

Such as the oxidation of the base, alcohol, $\begin{matrix} CH_3 \\ | \\ CH_2\text{-}OH \end{matrix}$ over into the acid corresponding (the acid in vinegar), $\begin{matrix} CH_3 \\ | \\ CO\text{-}OH \end{matrix}$.

The illustration as it stands is sufficient. It shows the subject presented not as a carefully completed, rounded and exact definition on the first page, which is calculated to wonderfully astonish the pupil and tax his memory only—not his reasoning power; but presented like the learning of a child, as a part-truth at first which grows with his capacity for understanding.

It may be that there is something parallel to this cumulative work in the modern teaching of physics, but if so my ignorance of it must be excused, for this is what I have found generally surprises the teacher of physics if he takes up the subject of chemistry—the fact that we get in upon the student's mind, blow

upon blow, in lecture, in recitation, in laboratory and in the laboratory-quiz, these two ideas of the acid and the base; and that in a few weeks all of this is repeated from another standpoint and in connection with other apparently different elements.

It would seem, then, that general chemistry properly presented has a lesson to teach to the physicist in the attainment of that systematization of his subject which is the goal of all science. Chemistry has been growing from the early cataloguing stage, through the statistical to the systematic. The time has come when physics should be presented more and more as a correlated subject. The grand divisions of general physics will gradually fade from the student's sight and some unifying thought such as the dynamic laws, will classify the whole course.

II.

There remains now to be discussed the second division of my argument, namely, the conduct of the laboratory. Upon this I will touch lightly, only reminding you in passing that the laboratory is a school for thought and quick wits. Those important theories and generalizations which, by their very momentum, have swept past the student's mind or attention in the classroom, may be held up, close to the practical test, in the laboratory and there seem foolishly simple. Anything, however slight, which coördinates this laboratory work is of value.

In physics the expense of individual apparatus has made it necessary in most of the laboratories to devise a peculiar system by which the apparatus must stand still and the student experimenters file past—much like the endless procession on the golf course. If those who are ahead lag, one almost expects to hear the cry "Fore" and see the more skilful couple pass on to the next hazard or fair-green, as the case may be.

A second Woodhull of your Teachers' College is needed to take hold of the apparatus and simplify and cheapen it. Although I have never visited the laboratory of the great Quincke of Heidelberg, I understand from those who have been there, that it is a museum of deliberately simplified physical apparatus. A spectroscope is shown, skeletonized without even the protection of a paste-

board tube. The collimator-slit is visible on both sides so that the rays of light can be traced, passing thence through the lens, parallel—the lens supported in a cork—passing through the prism diverted but parallel. And beyond the prism and the second lens a card held as a screen will show the spectrum. Unimportant details cloud the understanding of the pupil. The polished brass enclosing the usual spectroscope diverts the attention. Pupils are present in the laboratory for physics—not brass.

Much has been done in the laboratories in general chemistry toward simplification of apparatus from which I believe the physics teacher could learn something. In my own laboratory as in many others, every student or every pair of students (for they generally work in pairs) has his own little kit of apparatus which lasts him through the year's course and from which, like children's blocks, he makes every combination of apparatus throughout the year. In this way during the unit period of two hours the whole division is working simultaneously on the same exercise so that the instructor is enabled to give individual attention to his students without performing extraordinary mental gymnastics.

If, for a single illustration, the subject is *hydrogen chloride and hydrochloric acid,* all the men in the laboratory division set up their apparatus at the same time and (in the same way) study their three products, *i. e.,* the dry gas, the solution of hydrochloric acid and the by-product, sodium sulphate. While this work is actually in progress, the instructor may pass from one pair of students to another, plying them with questions on their idea of the experiment, knowing exactly the stage of the student's work and the difficulties he is likely to encounter. Also the fact that the work is unified makes it possible either at the beginning or at the end of the exercise for the instructor to reserve a few minutes for the assembling of the division as a whole in the recitationroom. Here a rapid class-quiz is held either on the work of the previous laboratory period or on their conception of the work they are about to undertake, or (if the quiz comes at the end of the exercise) on the work just completed. "How do you handle your big classes?" one of our genial professors was asked. "I get them *together* and turn the hose on them and something sticks."

In the laboratory this unification of the class work, principally to be obtained by simplification of the apparatus, is as important as the systematization of the theoretical subject in the lectureroom.

Advantages accrue in this system both to the teacher and to the pupil. We all know the argument of the political economists for the so-called "division of labor"—that the distraction and waste of time incident to passing from one kind of labor to another is eliminated by having for the laborer one kind of occupation instead of many. The farmer makes more money farming than he does by stopping to mend his own farm utensils. In the same way the teacher is so much more valuable as a teacher who has his class together on a single piece of work on the same day and who can refer any one of his class back to the previous laboratory period for a definite illustration or comparison, useful to the work in hand.

How is it with the instruction in the physics laboratory? One of your teachers said to me some time ago, "There are six subjects going at once and the teacher has but one tongue and two feet." Under these conditions he necessarily relies on instruction cards. The alert boy, if he is earnest and does not understand his instruction sheet will come to the teacher for explanation. "If—" but that is a big "if"! I have seen the boys in a calculus class at Johns Hopkins University fight for the front seats that they might lose nothing which the professor had to say. Instruction sheets could not create this enthusiasm. With the best of instruction sheets and "six subjects going on at once," the teacher concludes: "At the end of two hours, you know you're dizzy and you wonder what the lads have learned."

Advantage accrues not only to the teacher by unification of the laboratory work but to the pupil. For him there is all the advantage—to borrow again from the economists—of *esprit de corps* and the community of interests, from comparing notes and his own conclusions with those of others. As an illustration I asked a student the other day what could be done with a chloride that could not be done with anything else in the world. Though a bright student, he did not know. The next man answered correctly: "Make chlorine from it." So simple was the answer, so

a matter of course, the one who had passed the question sank back into his seat with a sheepish look of aggravation. Such simple ideas as these—the most important of all—do not come from instruction sheets. Such lessons in alertness come from the equal, not the instructor. Physicians find that feeble-minded youth are happier and learn more by being placed together; that our children learn more from the children of the schools than from the protection of the home and association with only those of a grade above them. Far be it from me to decry the influence of the teacher in the laboratory, but let us not by individualizing the laboratory experiments cut out from our pupils the added advantage obtainable from the intellectual peer.

I have said that physics and chemistry are sister sciences. That chemistry *owes* much to physics is clearly understood. That chemistry has learned and is learning much from physics needs no demonstration. We have only to point to the great advances which chemistry has recently made in the theory of solutions, borrowed from the mathematical laws of the physicist, to show how impossible it would be for chemistry to progress, did we not have at hand the great generalizations of physics. It is a pleasure, therefore, to strive to repay the physicist, to a slight extent, by offering to him a little of value which he may learn from chemistry.

I have, therefore, endeavored to establish the proposition that in the teaching of chemistry, simpler and because simpler more valuable, methods are being used than are found in physics. These methods are:

First, in the classroom, coördination of the entire subject of the course in general chemistry under one leading root-thought.

Second, in the laboratory, the organization of classwork as more advantageous to both teacher and pupil than isolated individual work.

Whether these advantages are possible in chemistry and impossible in physics is a question for my audience to decide.

Enough, I hope, has been said to show that pedagogically physics may have something of methods to learn from her sister science.

BIOLOGY AS AN ADDED INTEREST IN LIFE.*

BY A. J. GROUT,

Instructor in Biology, Boys' High School, Brooklyn, N. Y.

Lecky, in his "Map of Life," makes this statement: "It is one of the laws of our being that by seeking interests rather than by seeking pleasures we can best encounter the gloom of life." It is the idea that biology may become, if properly taught, an added interest in life, and the ways in which we can so teach it is what I wish to present briefly to you tonight.

The studies of our high school courses may be roughly divided into two classes—those which are usually and properly dropped at the close of the school or college course, under ordinary conditions, and those which can be pursued throughout life with pleasure as well as intellectual gain.

In the first class belong the mathematical studies, formal language study and the greater part of physical science. Among the latter are music, literature, history, and, last but not least, biology in the form commonly known as "nature study."

I can readily recall the time when the study of English meant rhetoric and grammar, with a study of brief sketches of the lives of some prominent authors for a finishing touch. The study of English literature in the sense of familiarizing the student with what was noblest and best in the literature of the language was scarcely thought of by the great majority of teachers. Happily that is changing, and it is readily granted that the best teacher of English is he who trains the student not only to use his mother tongue with accuracy and grace, but also to appreciate and love the best that has been written. The solace and comfort, the uplifting and cultivating effect of the love of good reading has long been recognized, much longer than it has been recognized that one of the teacher's chief duties is to develop that love.

A similar change is coming over our ideas of science teaching, and it is coming to be recognized that while the study of

*From a paper read before the New York City Association of Biology Teachers at one of their regular meetings.

animate nature is invaluable in training the powers of observation and inductive reasoning, and that the study of some topic like physiology is essential for the highest physical welfare, yet if all this be done and be the end, the teacher's task is poorly performed. The facts we can teach are but few, the training in observation and reasoning is all too brief, but if the student be left with the power and the desire to know more, then all the benefits of our work will be increased a thousand-fold by being continued throughout life. Anxiety and *ennui* are the Scylla and Charybdis of human life, but the love of nature will enable one to steer clear of both. What more refreshing to the weary, anxious worker than days at the seashore or in the mountains if he can but forget his troubles and his anxieties? If he can not forget, illness, insanity or death await. What so sure, so speedy and so delightful a manner of forgetting as to fill one's eye and mind with the beauties and secrets of nature? The mind at such times is like a vessel filled with poisonous gasses that can only be emptied out by filling with the healing liquid of entertaining and engrossing pursuits.

The study of nature is a still more effective prevention and remedy for *ennui;* one can never exhaust the secrets and surprises of organic life; there are enough problems in a single insect or plant to occupy an active mind for a lifetime.

The increasing numbers in our large cities who seek relief from care or *ennui* in the saloon, in the poolroom, at the racetrack and in sensual indulgence have aroused the solicitude of our most thoughtful men. If the science teacher can help his pupils to a state of mind where saner methods of recreation and entertainment shall be appreciated and indulged in, he will have done society an immense service.

The evils of a misdirected search for mental relief are not confined to the city. For "bridge" the country woman substitutes gossip; for the saloon there is the village loafing place, with its foul air and fouler speech; there is also the unbearable loneliness of the isolated farmer's wife, so strongly affecting the mind as to produce a characteristic type of insanity.

Books, art, music these may not be accessible, but all around the country home is an unknown world, filled with beauty and charming surprises, but which is rarely revealed except the revelation be begun in youth. The teacher is often the only one who can make the revelation, and though the study of nature can furnish the same training given by other studies, I submit that its chief object should be to add that to life which it alone can give and which other subjects can not impart.

How can you make your pupils love Nature? Love her yourself. Search out her hidden processes, her secret ways. If you know only what is in the book your pupil will never desire to know more. If you become an investigator you will become an enthusiast. Without enthusiasm one can not teach biology so as to make it a new interest in life.

There have been in the past a number of enthusiasts with little knowledge that have almost brought enthusiasm into disrepute. The enthusiasm that I plead for is the enthusiasm to know more, and if this be present the lack of knowledge will take care of itself.

The student trained under such a teacher may not be a walking cyclopedia of facts or a dictionary of technical scientific terms, but he will be one with trained eye and alert mind, obeying the mandate of the poet to "go forth under the open sky and list to Nature's teaching."

THE RATIO OF QUANTITATIVE TO QUALITATIVE EXPERIMENTS IN CHEMISTRY.*

BY DR. H. P. TALBOT,

Massachusetts Institute of Technology.

The introduction of quantitative experimentation into courses of laboratory practice in general or inorganic chemistry may be justified on at least three grounds—first, because work of this character serves to demonstrate the advantage of care and neatness in manipulation and in the keeping of laboratory records; second, because through such work the principles taught in the classroom, which are only too likely to become abstract and often vague notions, tend to take a concrete form in the mind of the pupil, as, for example, the law of definite proportions, which is easily demonstrated by simple experimentation, within the capacity of the beginner; and, third, because the results of quantitative work furnish a basis for comparison and discussion which tends to stimulate community of interest among the pupils, and permit each to measure his own attainment by the work of his neighbor, or the class as a whole.

On the other hand it will be conceded that quantitative work demands, for success, more constant attention to the individual on the part of the teacher; that it consumes more of the time of the pupil, and so restricts the range of experimentation; and that the "quantitative sense" in chemistry is not always readily acquired. In physics, the quantitative measurements are a refining of observations made with measures of length, capacity and weight already essentially familiar to the pupil, while in chemical manipulation quantitative accuracy depends upon the avoidance of a loss or gain of material which is not so easily appreciated by the beginner in connection with unfamiliar procedures and novel forms of apparatus.

A secondary school course of instruction in chemistry should, in the speaker's opinion, be primarily designed to give the

*Read at the December, 1903, meeting of the New England Association of Chemistry Teachers.

pupil as wide a knowledge of the facts of the science as is compatible with reasonable thoroughness. It should not avoid the simpler fundamental principles and laws, nor should it, on the other hand, include much chemical theory; it should be serviceable alike for the pupil who will pursue the subject in college and for his less fortunate companion. How, in such a course, the ratio between qualitative (descriptive) experimentation and quantitative work shall be chosen can hardly be set down in general terms. The fortunate teacher with small classes and good equipment will doubtless find it helpful and expedient to include a considerable number of exact experiments in his course, while the overtaxed instructor will meet with a larger measure of success from qualitative work. It should always be borne in mind that a considerable proportion of the instruction will necessarily be of the qualitative sort, and that work of this character is in no way inferior to quantitative work in its demands for painstaking instruction, even though the necessity for constant attention to the pupil may be less. Similar consideration with respect to the time devoted to the subject in a particular school will often be a determining factor.

A MODIFIED DEMONSTRATION PRESSURE GAUGE.

BY EDWIN H. HALL,

Professor of Physics, Harvard University.

The following drawings illustrate certain improvements in the construction and use of the demonstration pressure gauge which commonly bears my name. The general features of the instrument I need not dwell on, as they have been known to teachers for many years. Some of the changes to be pointed out are of my own devising, while others are not.

1. The rubber diaphragm, *C* (Fig. 1), is now in the form of a cap, which can be slipped on across the mouth of the glass cup, making a water-tight junction without use of string or cement.

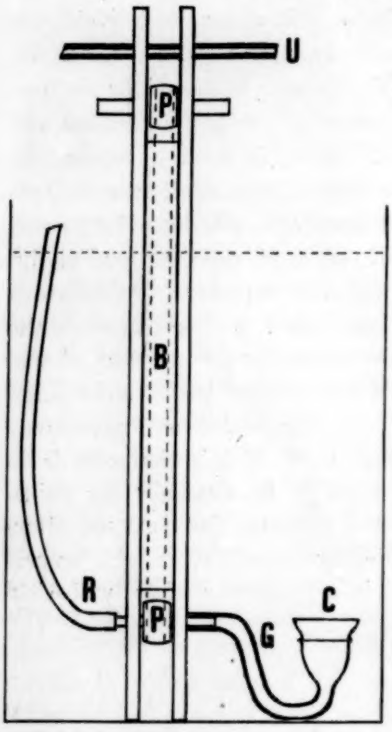

Fig. 1.

2. The glass tube *G* is cemented to a short brass tube, which makes a close fit in the lower hard-rubber pulley, *P*, and leads across to the rubber tube *R*.

3. The two pulleys are made barrel-shaped, "crowning" in the middle, to keep the rubber band, *B*, indicated by dotted lines, from working off to the side and jamming.

4. The glass index tube, *I* (Fig. 2), which carries the index thread of water, *T*, is made with a side branch near one end. The rubber tube, *R*, is connected with this branch, while the neighboring end of the tube *I* is provided with a short rubber tube, on which is a pinch-cock. This arrangement

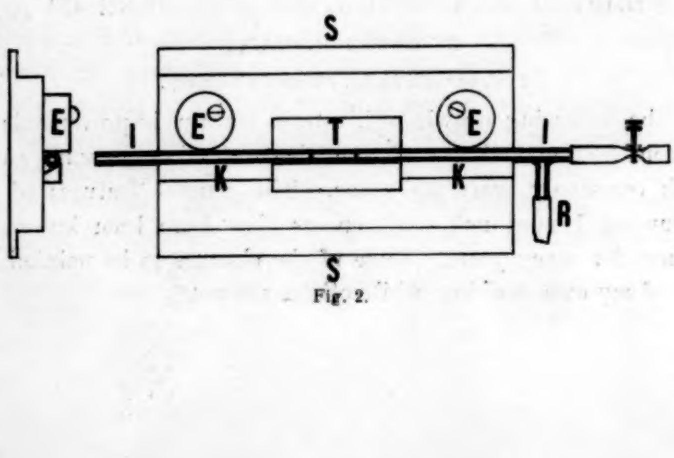

Fig. 2.

enables the experimenter to adjust the position of the index, T, at will, after the diaphragm end of the apparatus has been placed at any desired depth in water and has acquired the temperature of the water.

5. The index tube, which in ordinary use is borne in position U (Fig. 1) by the same pillar which carries the rest of the appartus, is for lecture-table use fastened upon a wooden lantern-slide, S (Fig. 2), being gripped there between two cleats, K and K, and two eccentrics, E and E.

A SIMPLE DEVICE FOR ILLUSTRATING THE PERIODIC LAW.

BY CHARLES BASKERVILLE,
Professor of Chemistry, University of North Carolina.

Any device for simplifying the perception of a great truth or principle on the part of students is acceptable to teachers. This is especially true of instruction in science.

Fig. 1.

The two accompanying photographs illustrate a "trick" of the writer who bases his instruction of elementary college students in chemistry on the periodic system.

An ordinary curtain pole is planed to present one flat surface. Blocks are then sawed from it 1, 7, 23 and 39 cms. long. The pole is then shaved to present two flat surfaces and cut into blocks 9, 24 and 40 cms. long; a third surface and so on until the remainder of the pole exhibits seven flat sides, when blocks 19 and 35.5 cms. are sawed off. The whole idea is now apparent to the reader. The lengths roughly indicate the atomic weights, the plane surfaces the valence of the elements in question. The so-called electro-positive blocks are stained blue and the negative red; those standing for carbon, silicon and titanium are half and half. Each block has the symbol and atomic weight in whole numbers indicated.

They are set up before the class in the order of their ascend-

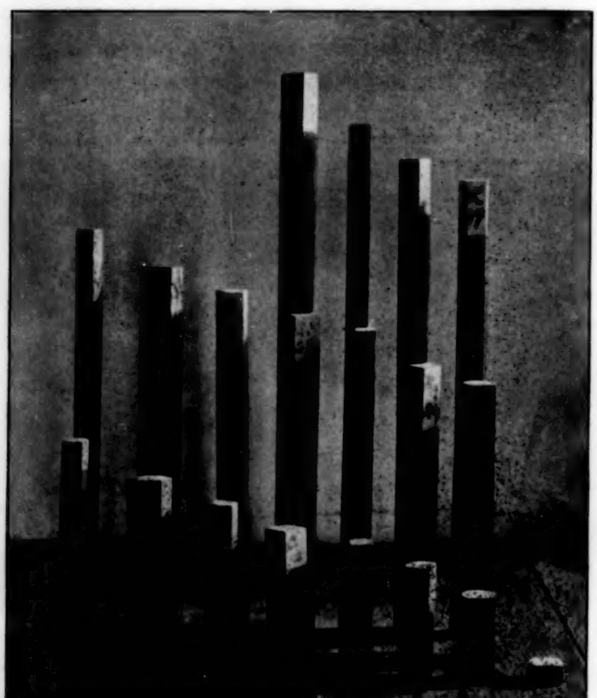

Fig. 2

ing mass values, as shown in the first photograph. Immediately certain facts become apparent, as, for example, at regular intervals we have blue blocks, at others red. Further, the first blue one has one plane surface, the second two; the last red one in each group seven, and so on. The thought of classification comes to the student at once and the blocks are rearranged according to the second photograph. He sees at once that the elements may be classified according to their atomic weights, the only invariable and measurable property they possess as far as we are aware at present, and at the same time the arrangement satisfies efforts to classify the elements according to their affinity, valence and electro-chemical characteristics.

No analogy can be pushed too far, and, to be sure, a little legerdemain is practiced in directing attention away from the unobtrusive hydrogen. The idea is quickly grasped, as the instructor notes in the faces of his pupils. It has been the custom of the writer, immediately such observation is made, to sweep the tableau from the lecture table, else some facetious youngster or dullard might describe potassium as "a stick thirty-nine centimeters long," etc. Some 600 examination papers, without exception, have given a clear conception of the "periodic law" (?) as the result of the use of the above, whereas formerly many failed entirely to grasp the idea.

Metrology.*

THE METRIC SYSTEM PSYCHOLOGICALLY CONSIDERED.

BY WILLIAM F. WHITE.

(*Continued from page 522.*)

Suggestions of a system on a sound basis appear in the seventeenth century, and even earlier. The first proposals made to legislative assemblies for a complete decimal system of weights and measures were made almost simultaneously in France and the United States. Such a proposition was made to the house of representatives of the United States on the fourth of July, 1790, by Thomas Jefferson, who had been minister to France. His scheme was to make a foot (which should be one-fifth of the length of a seconds pendulum) the unit of length. There were to be ten inches in a foot, ten feet in a "decad," etc. All the tables were to have the decimal scale, which had already been established for the coinage. The plan was not adopted.

Earlier in the same year Prince de Talleyrand, then bishop of Autun, urged upon the constituent assembly of France the necessity of reform in weights and measures. A decree providing for investigation and conference was adopted by the assembly (May 8, 1790) and approved (August 22) by the king, Louis XVI. The system was evolved by the French academy of sciences in conjunction with delegates from Spain, Italy, the Netherlands, Denmark, and Switzerland. Great Britain declined to participate. It had been decided to take as the unit of length the ten-millionth part of the quadrant of the earth's meridian. A trigonometrical measurement of the meridian arc extending from Dunkirk to Barcelona was made by the eminent French mathematicians and astronomers Delambre and Méchain. The work, which was not only laborious but dangerous, occupied seven years. It was completed in 1799.

* Communications for the Department of Meteorology should be sent to Rufus P. Williams, North Cambridge, Mass.

Meanwhile, as the result was approximately known beforehand, the system was provisionally adopted in France, and the nomenclature chosen.

The French revolution broke out in 1789. Its progress was contemporaneous with metrological reform. The spirit of change was favorable to the decimalization of weights and measures. This reform had been sanctioned by Louis; it was also by Napoleon when he came to power. Monarchy, reign of terror, convention, consulate, empire: one form of government succeeds another with dizzy rapidity; but the metric system is championed by them all.

It was carried almost all over southwestern Europe by the conquering arms of Napoleon. At the downfall of the empire, all these countries threw off the metric system because it had been imposed by a victor. But they all, having had a trial of it and learned its advantages, returned to it and adopted it voluntarily. A relapse in France itself toward the old system (tolerated by law of 1812) was checked: from January 1, 1840, the old system was forbidden.

From about that time the spread of the metric system has been steady and far reaching, until today it is the system of weights and measures of practically every civilized nation of the world, with the three important exceptions, the United States, Great Britain, and Russia. The most important adoptions of the metric system in the last third of a century have been by Austria-Hungary, Norway, Sweden, and especially Germany. The most recent exclusive adoption by an important European state was by Sweden (compulsory law effective January 1, 1889).

In 1875 twenty-two nations agreed to a convention establishing the international bureau of weights and measures. It constructed an international prototype meter and an international prototype kilogram and very accurate copies of these for each of the signatory powers.[8] France gave for the use of the bureau a

[8]The degree of accuracy of the comparisons may be seen from the equations expressing the relation of meter no. 27 and kilogram no. 20 of the U. S. to the international prototypes (T represents the number of degrees of the centigrade scale of the hydrogen thermometer):

$$\text{M no. } 27 = 1\text{ m} - 1.6\mu + 8.657\mu T + 0.00100\mu T^2 \pm 0.2\mu$$

$$\text{K no. } 20 = 1\text{ kg} - 0.039\text{ mg} \pm 0.002\text{ mg}$$

U. S. coast and geodetic survey. *Weights and measures; the national prototypes.* Appendix no. 18, report for 1890, p. 754, 756.

tract of land in the Park of St. Cloud, near Paris—"the only piece of land in the wide world whose entire neutrality is absolutely assured."

The metric system is used almost exclusively in science in all lands. It alone is used in the international postal service. It was reported by the Decimal association of England to be, at least theoretically, the exclusive system of 448,000,000 people in the world. It is the standard in thirty-six nations, permissive in three, forbidden in none.

Russia made the use of the metric system permissive in 1901. That action was taken by Great Britain in 1864, but was practically annulled by an act of 1878. Permissive use was reestablished in 1897, and now there is an active movement for a law making it compulsory.

The United States constitution (article 1, section 8) devolves upon congress the power to "fix the standard of weights and measures." This is "almost the only power clearly and expressly vested in Congress by the Constitution which has remained practically unexercised to the present day."[9] A law approved July 28, 1866, makes the use of the metric system optional. In 1893 the office of weights and measures was authorized by the secretary of the treasury to regard the meter and kilogram as fundamental standards, from which the customary units are to be derived. The office of weights and measures was made the national bureau of standards by act of congress approved March 3, 1901 (effective July 1). Dr. S. W. Stratton was appointed director of the new bureau.

The metric system is employed, wholly or in part, by various branches of the United States government: by the coast and geodetic survey (from the beginning), the agricultural department, the mint (for some purposes), the marine hospital service (since 1878), the department of the surgeon-general of the navy (1885), also of the army (1893), and the custom houses of Porto Rico and the Philippine islands.

It is employed to some extent in museums, and has long been in use by the American Library association. The most

[9]Report from committee on coinage, weights, & measures, on H. R. 2758. Report no. 795, 54th cong. 1st ses. p. 1.

progressive workers in pharmacy and medicine are using the metric system. It is used almost entirely in pure science and in electrical work. The rapid growth of electrical science and its manifold applications made necessary authoritative standards of electrical measure. The law of July 12, 1894, which met this need, bases all electrical units on the fundamental metric units (and on the second of time).

A few enterprising American manufacturers have found it advantageous to use the metric system without waiting for its general adoption.[10] Wherever used, the results are satisfactory. Many would like to use it if others would. The scope of its application is widening. But in the United States, outside of its use in pure and applied science, the beginnings are still small. Its use in American commerce is very limited. What is needed is a signal for general adoption, in the form of legal enactment.

Recent attempts toward enactment for government use of the system began in 1896, when a bill passed the house of representatives by a majority of two. That vote was immediately reconsidered and the bill recommitted and not afterward taken up. In the second session of that congress (54th) a bill for the introduction of the metric system was favorably reported to the house, but no action was taken. No reports on the metric system were made by the committee on coinage, weights, and measures during the years 1898-1900. Representative John F. Shafroth, of Denver, introduced a bill "to adopt the weights and measures of the metric system as the standard weights and measures in the United States." This was favorably reported March 1, 1901, but no action was taken by the house. Similar effort later has had similar result. The friends of metrological reform in the United States grow year by year stronger, more persistent, more hopeful. National adoption is generally regarded as only a question of time.

TEMPORARY INCONVENIENCE OF CHANGE OF SYSTEM.

The misapprehensions and exaggerations, to be met with in some quarters, respecting the difficulties that will be encountered

[10]Among these may be mentioned the Solvay Process Co., of Syracuse, N. Y., the Merrimac Chemical Co., of Mass., the Bausch & Lomb Optical Co., of Rochester, N. Y., the Library Bureau, and the Waltham Watch Co.

in changing from the customary to the metric system, are curious illustrations of the absurdities to which speculation may go when it has left all solid basis of fact. One newspaper writer enlarges upon the loss that will be inflicted upon the railways of the country by the necessity of changing the width of the tracks! Millions of invested capital to be thus disastrously affected! The width of the track is not now any whole number of feet or even of inches; why should it be necessary to make it a whole number of metric units of any denomination? Instead of saying as now that the width of the standard track is four feet eight and one-half inches, inside measure, with a tolerance of error of from one-sixteenth inch to one-eighth on curves, we shall say that the width is 1.435 m, with a tolerance of from 1.5 to 3 mm. And the trains throughout the land will continue running on the same tracks while we are changing our expression of a fact. It is indeed the "abiding delusion" of those opposed to all metrological improvement, that you change a material fact when you change the notation in terms of which it is expressed.

When the metric system becomes the popular system in this country, it will doubtless be found advantageous to have most new machines made in metric dimensions. The loss and physical inconvenience resulting from the adoption of a new system will be considerable where even gradual changes are involved. But the compensation will be ample. And when shall we be able to make the change with less loss or inconvenience?

With regard to the difficulty of thinking in terms of a new system, it is recognized by all that the change will not be made by persons who, at the time of the legal adoption of the metric system, are in middle life or older and who are not engaged in educational, industrial, or commercial pursuits. They will live and die thinking in terms of the old weights and measures, as was the case in every metric country. One may still hear old persons in this country talk of shillings. The tendency to fixity in such minds is too strong to be overcome; and there is not sufficient interest in the change to give rise to an effort. This inability to change seems strongest in such matters as notation, or language in general—matters that were learned as an arbitrary convenience

in youth and can not now be unlearned. The tendency as the mental powers begin to weaken to revert to forms of speech used in childhood, is matter of easy observation. Among those, especially the illiterate, who have learned English (or other language) later than childhood, the foreign accent is sometimes more marked at seventy years than at fifty, the reversion to earlier forms more than balancing the effect of added years of practice. Similar is the tenacity—the helplessness—with which they cling to the weight, measure, and value units of youth. This fixity must be recognized: it is, in these circumstances, a law of mind. We are not to expect the impossible. But the influence of those who are psychologically incapable of adjustment will no more interfere with the national movement than it did with the adoption of the metric system in Germany, or than it did with the adoption of decimal coinage in this country. No one thinks that we should today be without the advantage of a convenient coinage because there are those who still say that a workman gets "twelve shillings a day." Even those who say "shilling" would not wish a return if it were proposed.

Moreover, such do not control popular movements. The young of course change easily; while all those in active life, educational, commercial, industrial—who touch shoulders and exchange views with others that have vital interests—use weights and measures, directly or indirectly, at almost every turn. To all these, the change to a better system is rapid and satisfactory. In a sense, life and education may be measured by the ability to overcome mental inertia.

(To be Continued.)

Book Reviews.

Outline of Elementary Chemistry. By WILHELM SEGERBLOM, A. B., Instructor in Chemistry at the Phillips Exeter Academy, 12 × 18 cm., 21 pages. The News Letter Press, Exeter, N. H. **1903.**

This outline is designed to give a birdseye view of the first year's course in chemistry in the Phillips Exeter Academy, and was prepared for the purpose of classing together the isolated points learned during the year in a more complete fashion than they could be classified at different times during the year. The outline gives to the student a better grasp of the year's work as a *unit*, and enables him to see more clearly the connection between the different parts of the subject and their bearing upon each other.

Teachers of chemistry will find much that is suggestive in this pamphlet, and it may well serve them as a model for similar outlines of their own courses.

C. E. L.

Laboratory Experiments in Chemistry. By B. W. PEET. 13.5 × 16 cm., 98 pages. Fred Coe, Ypsilanti, Mich., 1903.

The laboratory directions contained in this book represent the course as given at the Michigan State Normal College. The selection is excellent, and the directions apparently ample and specific enough to warrant a successful performance of the experiments as well as an intelligent appreciation of their meaning. The name of each experiment is given—a very good plan, for the student may then have during the performance of the experiment the central thing in it ever prominent in mind.

Quantitative work as well as the modern notions of physical chemistry receive attention in experiments which are certainly quite within the powers of secondary school pupils.

Altogether the Manual is to be recommended, and its use will certainly give a well rounded-off knowledge of chemical facts and laws.

C. E. L.

Reports of Meetings.

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS.

The eighteenth meeting was held in Boston, December 5, 1903. After the routine business the following officers were elected for the ensuing year: Lyman G. Smith, president; Albert S. Perkins, vice-president; Harold Bisbee, secretary; E. F. Holden, treasurer; Laura P. Patten, N. Henry Black and George W. Earle, additional members of the executive committee. Susan L. Mara, of the South Boston High School, and Charles E. Fisher, of the Providence (R. I.) Normal School, were elected members.

The entire morning was devoted to the reading and discussion of the report of the committee on high school course of study. The report was read by Chairman Albert S. Perkins, of the Dorchester (Mass.) High School. It was based on replies received in answer to ten questions. Mr. Perkins summarized as follows:

"A majority of the sixty-seven teachers who replied to the circular think that mental discipline joined with information should be the motif of a secondary school course in chemistry; that this course should be given in the third or fourth year; that more than half the time should be given to laboratory work; that the average pupil ought to perform fifty or sixty long experiments; that more than half of the prepared and class room work should be devoted to the descriptive aspect of the subject, most of the remainder to the theoretical and mathematical, and a little history should be worked in incidentally; that very few formal lectures should be given, but that the teacher should perform many lecture experiments, and introduce new subjects provided he make the pupils do most of the talking, and finally, that the modern theories of physical chemistry like electrolytic dissociation and the mass law should be taught in a simple and elementary way."

The various questions considered by Mr. Perkins were then enlarged upon by different speakers.

The Year of the Course in Which Chemistry Should Be Begun.—K. W. Thompson, Beverly (Mass.) High School.

"The year in which chemistry should begin must depend on the conditions existing in each high school. I will outline briefly the chemistry and physics courses as they are at present in the Beverly High School.

"The ninth grammar grade is a part of our high school, making practically a five years' course, which is purely elective.

"In the first year we try to lay a scientific foundation by teaching the elementary physics and chemistry of air and water. The study of air brings out the properties and uses of oxygen, nitrogen, carbon dioxide, water, and dust in the atmosphere. The weight of air, wind, windmills, gas engines, hot air engines, anemometers, and gas meters come under physics. Under the subject of water is hydrogen, composition of water, its weight, its boiling and freezing points, purification, dew point, condensation, rain gauge, ocean currents, convection, pumps, and water wheels.

"During the first year of high school proper we give an elementary course in physics, taking up mechanics of solids and liquids, light, electricity, and heat, with the simpler mathematical problems to illustrate the subject.

"Chemistry is taken up the second year in high school. After their ninth grade training in the chemistry and physics of air and water, the pupils ought to be well fitted to take up the real study of chemistry.

"I find that they can understand enough of the modern theory of chemistry to pay for spending four or five weeks on the subject toward the end of the year.

"Harvard physics is taken up during the third year with Hall & Bergen, Avery, and Snyder & Palmer's 'One Thousand Problems in Physics,' as texts.

"During the last year of the high school course qualitative analysis is studied and those going to Harvard review their chemistry of two years before, doing, in addition, the experiments in the Harvard pamphlet not in our second year course."

The Number of Hours a Week That Should Be Devoted to Chemistry.—Wilhelm Segerblom, Phillips Exeter (N. H.) Academy.

"In answering this question, I can speak, not from the standpoint of the high school teacher, but only from experience gained in teaching chemistry at the Phillips Exeter Academy. There the class has four full hours of recitation work per week, devoted mainly to discussion of the laboratory, at such hours as suit their respective schedules best; they are expected to do the work within the week between the assignment of the lesson and the review of it in class. Six hours per week have been found ample for the experimental work, making a total of ten hours per week. No additional time is required for outside preparation, as there is practically no memorizing from a descriptive textbook.

"The time demanded at Exeter is in close accord with the time which the committee on college entrance requirements of the National Education Association, college teachers, and teachers in secondary schools all would insist upon; *viz.,* nine or ten hours a week.

"It is of interest that at Exeter in one-half the courses in mathematics, one-half the English, practically all the modern languages and

all the science, four hours per week are devoted to recitation. Lessons are given of such length that about six hours per week of outside preparation are necessary. This shows that chemistry has a definite place and a fair amount of time assigned to it in the school curriculum.

"One thing to be noted is that a pupil is not necessarily studying chemistry because he 'spends so and so many hours per week on chemistry or in the laboratory.' That pupil is studying chemistry who is getting an intimate acquaintance with chemical substances through making them, studying their properties, noting how they behave with each other, and then getting at the Why of it all."

The Number of Experiments That Ought to Be Performed by the Pupil.—Sidney Peterson, Brighton (Mass.) High School.

"I shall consider the word 'experiment' in a broad sense, and understand by it the search for a number of simple truths which may be grouped together as one.

"The great value of one experiment, including a number of operations, over an experiment consisting of but *one* operation is, that the truths thus learned are more intimately associated and the correlation of facts is more easily accomplished.

"The majority of high school teachers require their pupils to perform from fifty to sixty experiments during the year, each experiment occupying one full laboratory period for the average pupil. A *larger* number of experiments than this necessarily means that the amount of *quantitative* work is lessened. This seems a great pity because it gives the pupil a wrong conception of chemistry. Under the circumstances chemistry to him is *not* a *science,* for without *exactness* a subject is not a science. The laws of chemistry have but little meaning to him if he has not proved them in the laboratory.

"This training in exactness and detail is an important matter. It is not only the foundation of all good work in chemistry, but it leads to interesting research work—it teaches the pupil to work out the problem for *himself* and to go even farther—to think."

The Portion of the Prepared and Class-room Work That Should Be Devoted to the Historical, Descriptive, Mathematical and Theoretical Aspects of Chemistry.—Miss E. V. Sampson, Cambridge (Mass.) Latin School.

"In an elementary course in chemistry there should be some theory; obviously the atomic theory and the allied theories, law of definite and multiple proportions, Avogadro's so-called rule, law of mass-action, Berthollet's law, and, in addition, quite a little of the modern theory of electrolytic dissociation.

"One of the most interesting points in the theoretical part of chemistry is the classification of the elements; and this, toward the end or during a course serves to bring the various studies into one connected

scheme, and gives the pupil a good idea of the relations of the various elements and compounds according to modern views.

"The mathematical part of the course should be enough to give the pupil a thorough understanding of the meaning of equations, the calculations necessary for simple quantitative experiments, and for atomic and molecular determinations, bringing in the standard condition calculations. The mathematical part fits in very well with the theoretical.

"The historical aspect, in an elementary course, has a very small place. The pupil should know whether theories and laws are modern or ancient, he should know occasionally when certain compounds or elements were discovered; but anything beyond is unnecessary.

"Taking an average, I should say make about 60 per cent of the course descriptive, 25 per cent theoretical, 14 per cent mathematical, and 1 per cent historical."

The Use of the Lecture System in High Schools.—Miss H. M. Lambert, Lowell (Mass.) High School.

"The lecture method has a small place in a secondary school chemistry course. Its disadvantages are these: If notes are not taken, very little definite knowledge is retained, and vague ideas result. If notes are taken, owing to the pupils' inexperience in note-taking, they are almost worthless, and the attention has not been concentrated upon the lecture, so that very little that is definite and accurate is taken away.

"The method, however, has advantages. Practice in note taking is of undoubted value in college preparation. The greatest advantage of the lecture method, however, is that it can not fail to give the student a broader outlook over the field of chemistry. It is necessary for him to see the connection between his small work in the laboratory and that of the industrial world, and the relation of chemistry to everyday life. This is accomplished in some degree by constant reference to the wider application of facts and principles under discussion, but because these are fragmentary, they are not as impressive as material presented in a regular lecture.

"The best use of the lecture method is that of an occasional lecture on such subjects as electrolysis, photography, illuminants, etc., including theories simply stated, and a generous treatment of the actual applications of these theories and related facts. Historical lectures, bringing material into more systematic arrangement, than can otherwise be possible to students, are valuable."

The subject of text-books was discussed by Miss L. P. Patten, Medford (Mass.) High School.

In the afternoon the Association listened to an address on Radio-Active Substances by Prof. F. J. Moore, of the Massachusetts Institute of Technology.

L.

NEW YORK STATE SCIENCE TEACHERS' ASSOCIATION.

SECTION C, EARTH SCIENCE.

PROFESSOR AMOS W. FARNHAM, STATE NORMAL SCHOOL, OSWEGO, CHAIRMAN.

1. *Home Geography, Its Place and Purpose in Geography Teaching*, by H. Irving Pratt, commissioner, Orwell, N. Y. (Abstract.)

Home geography is the study of the origin and development of one's physical environment, and its relation to life. The life element is to be emphasized and the relations between life and earth are to be shown.

Study first the home surroundings—the store, where something can be learned about trade; the mill, where the different grains are made into flour; the stream, which furnishes power; the pond, the hill—all teach something of the wide world outside. The child should study the ways in which his own physical needs are supplied—the need of clothing, food and shelter. In this connection many elementary lessons can be taught about home industries. The study of storekeeping, farming and milling in this way become sources of great profit.

Ritter says: "Wherever our home is, there lie all the materials which we need for the study of the entire globe." There are the great earth elements—atmosphere, land and water. There are also plant, animal and human life; day and night; change of seasons. On these are based all the details of geography teaching. If, for instance, we study the glacial period, we may find evidences in nearly every school district of the state; kames, drumlins, waterfalls, "erratics," grooves and scratches, striated pebbles and boulders, even sands and clays. We can trace the influence of the glaciers on the human interests and occupations of the present.

Professor W. H. Scott, of the Porter School, Syracuse, opened the discussion, which became general and spirited. Dr. Jacques Redway, who was to have spoken upon the "Place for Commercial Geography," was, at the last moment, detained at home by an accident to a member of his family. Professor A. P. Brigham, of Colgate University, took his place and by a graceful impromptu address on Laboratory Work in Physical Geography demonstrated his ability to meet emergencies. Following is an abstract:

Field work is a part of the practical exercises in this subject. The proportion of indoor and out-of-door work depends on climate, available localities, equipment and organization of the school program. Difficulties in providing for field work will lessen, in time, as the prejudices against it are conquered and school authorities are convinced that they should give it needed time. Transportation is usually possible and inexpensive by street car or suburban service. The progressive teacher will learn the art of directing field work by doing it. The new teacher should visit the place beforehand and decide on the main points of instruction and then do the best he can by combined exposition and questioning. Pupils should take notes and review the excursion in class. Succeeding trips will develop many comparisons with phenomena seen before, and general principles will be unfolded by an inductive process. Perfect correlation with the order of subjects in the class room will rarely be possible and it is better to teach all that is within reach on an excursion. The teacher need not be afraid of the spirit of the naturalist.

The laboratory should be large and well lighted, with room for mapracks, trays of specimens, and a large laboratory table with individual

drawers. One side of the recitation room may be thus equipped. Double periods are desirable, but single periods are better than none. Maps are cheap and of high teaching value, and easily secured. Any teacher who tries can have a few rocks and minerals. Much can be done in meteorology with thermometers, barometers and weather maps. Teachers who are equipping laboratories will be helped by visiting some model laboratory in a high school or college.

This work once well begun will insure its own extension and can now be done to some purpose, not only for its educational value to all, but because it can now often be offered in entrance to college. The college entrance examination board will, for the third time, set an examination in the subject, in 1904. In this forty per cent of the count depends on the laboratory note book.

The last paper, in the absence of the author, was read by the chairman.

Our Geographical Textbooks; Their Strong Side and Their Other Side, by Margaret Keiver Smith, State Normal School, New Paltz. (Abstract.)

No better scheme of instruction in geography has ever been conceived than that of Comenius. The wonder is that it has not been more closely followed. It brings the textbook into use only in the highest department of the school. John Locke, contemporary of Comenius, introduced into England the plan of committing geographical facts *verbatim* from a book, the plan followed in all American schools up to 1860, at least. The reaction against the finality of the textbook was inaugurated by the Pestalozzian work at Oswego in the 60's and 70's, by Guyot's visit to America, the publication of the works of Humboldt and Ritter and the development of the Evolution Theory.

Today the development of geography as a science out in the world is in advance of the development of geography as a subject of school instruction. Practical workers in geography seem to attach no importance to the work of our school teachers or to the facts stated in our textbooks. Probably none of the geography teachers in our public schools has the qualifications for membership in any important geographical society in this or any other country. The aims of the practical geographer are very different from those of the teacher.

The working out of "causal relations" in geography requires considerable knowledge of the sciences. The attempt to impart this knowledge through the textbook swells it unduly with extraneous matter, often confused and undigested. The understanding of *explanatory* subjects is often more difficult than that of the subjects which they are alleged to *explain*. The effort to present the "human interests" of geography has resulted in much the same way.

Too many textbooks are written to fit the limitations of teachers; both author and publisher confess that the teachers cannot use a scientifically arranged book. In this effort to meet both teacher and pupil on their own low plane, to make the book easy, it often abounds in unscholarly, inaccurate and misleading statements. Unfortunately, we have no *best* books to use as standards. The textbook for the high schools ought to be the best effort of a geographer and a man of letters. There should be, also, textbooks for teachers, working textbooks, constructed on the laboratory plan of books in chemistry and physics.

SECTION B, BIOLOGY.

PROFESSOR JAMES H. STOLLER, UNION COLLEGE, SCHENECTADY, CHAIRMAN.

Correlation of Biology with Drawing and English, by C. Stuart Gager, Ph. D., New York State Normal College, Albany.

The purpose of art education in the high school should be to give power of appreciation versus power of execution. The chief aim should not be to train artists, but rather to discover the born artist or enable him to discover himself.

In biology, also, the aim is not to give technical training or to produce specialists, but to enable the pupil to come to himself—to give him an appreciation of living things, to help him to interpret his environment and conform to it. In how far may biology and drawing be so related as to be mutually helpful in attaining the main purpose of each, as stated above? Only to a very slight degree. One is analytic, the other synthetic. Their point of contact is the art of drawing, but the sole purpose of the drawing in biology is to record a fact, in art it is to express an idea or feeling or impression. The artist expresses himself; the scientist eliminates self and expresses nature. The artist draws a leaf to show the kiss of autumn and the warmth of Indian summer. The botanist draws the same leaf to show a serrate margin, palisade parenchyma, and pinnate venation. The purpose of the scientist is analysis, that of the artist synthesis. In the laboratory the pupil should confine his illustrations to simple line drawings. How the pupil annoys us who persists in concealing structure by his profusion of shading!

How shall the case be stated for English? There is certainly need among scientists of increased ability to express themselves well. What are the possibilities of correlation between biology and English? How can each help the other, and lessen the burden of work and ultimately benefit the pupil? The science excursion forms a good theme for practical work in narration, yet we can hardly ask the language teacher to accept accounts of field excursions in biology in fulfillment of all the requirements on Narration. In Description the biologic work may profit by the work in English, but this does not necessitate correlation, for the criteria of a good description demand powers in which high school pupils are usually very deficient. Composition is *par excellence* a literary study. To make it merely ancillary to science is to defeat its highest aims. Not many descriptive themes can be written in one year and but few of these can come from the science work without weakening the course in composition.

An attempt to force correlation to any great degree in high school work would only serve to bring confusion and lack of *definition*.

To conclude: Three facts render correlation of biology with drawing and English, and correlation in general in the high school, impracticable or undesirable: First, lack of community of purpose in the various subjects; second, change from an extensive study in the grammar grades to an intensive study in the high school; third, lack of agreement in the time when the studies are pursued.

The paper was discussed by Miss Harriet A. Curtiss, of Rochester, and Prof. Smallwood, of Syracuse University.

Correlation of Biology with Hygiene, by the Chairman, James H. Stoller.

We plead for a more extended and comprehensive course in hygiene in the schools; it should include more than is now taught concerning the nature and causes of sickness and the methods employed by modern sanitary science in preventing sickness. This work can be correlated with the

usual work in botany and zoölogy. Bacteria may be studied as a group of plants. A few cultures should be made and studied with the compound microscope. The zoölogy class, in studying the protozoa, should consider the amoeboid parasites causing malaria, yellow fever, smallpox and other diseases. Microörganisms *are* organisms and have as legitimate a place as any other organisms in the biology course.

The teacher must not be an alarmist. Teach that, as a group, the bacteria play a useful and beneficent part in nature. Show that nature has provided safeguards against the pathogenic organisms; that the healthy body withstands their incursions by the activity of its leucocytes and antitoxins. The following demonstrations are practicable in a biology course: (1) Microscopic examination of tartar from the junction of teeth and gums—from which, in 1683, Leeuwenhoek made the first descriptions of bacteria. Dental decay and diphtheria should be considered. (2) Bacteria of the air may be studied by gelatin plate cultures. This will illustrate the spread of tuberculosis. (3) Stained preparation of tuberculous sputum; show that tuberculosis is a preventible disease. (4) Potato culture may be used to demonstrate the bacteria of the skin of the hands. In this connection study contagion, and the application of quarantine to scarlet fever, smallpox, etc.; also disinfection. (5) Inoculation through wounds may be explained by reference to tetanus, etc. Note the peril of the toy pistol and the virtues of tetanus antitoxin. (6) An interesting and instructive laboratory experiment was described in SCHOOL SCIENCE of April, 1903, and reprinted in the July number of the JOURNAL OF APPLIED MICROSCOPY. It shows how flies transmit bacteria. From this we learn the necessity of treating the excreta of typhoid fever patients so as to prevent the possibility of germ transmission from them by flies. In this connection teach the relations of certain insects to disease; mosquitoes and how to prevent their breeding, etc. (7) Make two gelatin plate cultures, one of water from a sewage polluted stream and the other of water known to be uncontaminated. The contrast will be very marked and will show the means of preventing typhoid fever and other water-borne diseases. Explain the alternating saprophytic and parasitic stages in the life-history of these organisms.

The Advantages of a Year's Course in Biology (Zoölogy, Physiology, Botany), by Prof. William Dayton Merrell, University of Rochester.

The superiority of our modern courses in biology as compared with the earliest courses consists in the more prominent part played by laboratory work and the increasing emphasis of physiology and ecology. The study of zoölogy has passed from systematic zoölogy to morphology and physiology. The student of human physiology who has some knowledge of comparative anatomy needs less time for human anatomy and has more time for physiology proper. Besides, the study of the lower forms of life has taught him the essential nature of the fundamental physiological functions: nutrition, respiration, irritability, etc. These are known as functions of the cell, and the physiology of the higher animals becomes simply a division of labor between different kinds of cells.

In these respects botany has followed the lead of zoölogy, though it has suffered grievously at the hands of self-styled "biologists," who, in training and sympathies, are merely zoölogists. Botanists ask for no better training in botany than in zoölogy, but they do ask for just as good.

Physiology is to a good course in either zoölogy or botany very much what the juice is to an orange. The trouble with our old style botany courses was that, in our administration of the legacy handed down to us by Professor Gray, we made the mistake of leaving out the physiology. The result was that dried plants were considered nearly as valuable as

living ones, and often even more valuable, and we became mere dealers in baled hay!

Cell-physiology is valuable in that it leads to the employment of terms in describing the physiology of the plant in the same sense in which they are employed with animals. Botany has helped the other sciences by calling attention to the significance of environment and adaptation, taking the student into Nature's laboratory and showing that each plant and animal has its own life problems to solve. The student becomes more sympathetic and less selfish in his attitude toward the world.

The advantages of combining these three branches in a year's course of study become more apparent as their many points of contact are brought to light. And as the teacher's own horizon expands he will impart to his students a broader conception of life in all its forms, which is the supreme object before us in all our educational work.

Discussion by William D. Fisher, Delhi, N. Y.

The biological courses in our schools are too often underrated. Correlation of the several branches is either unknown or very imperfect.

Outside of educational centers, the old idea that science is heresy, especially that evolution is atheistic, still prevails. Even now some of the theological seminaries are turning out young men with such ideas. Therefore, if we can so improve our courses in biology as to present the facts of life and life development in better form than now, by all means let us change our methods. If, as Dr. Chamberlin thinks, the time is coming when specialization will, in large measure, disappear from scientific curricula, and our students will approach more nearly to the type of the older naturalists, then the substitution of the biology course for the three subjects as now taught separately is distinctly a step in advance.

Biology as a Cultural Study. What Are the Values of Biologic Science to Deepen and Enrich Individual Life, Intellectually, Morally and Esthetically, and How Best Are These Values to Be Realized? PROF. W. M. SMALLWOOD, Syracuse University.

No one cares to be regarded as a barbarian. But there are barbarisms of the mind, assumed or innate. Does one give evidence of barbarisms in his thinking or does he receive new ideas in a generous manner, placing truth above dogma and giving evidence of a willingness to trust the future? Culture has to do with the temper of the mind rather than its accumulated information. It was well defined by President Eliot in speaking before the N. E. A. His conception of culture is such that it may be approximated by every one, and its foundation is laid in the high schools. The sciences, especially biology, tend to lay this foundation.

Let us accept as a definition of culture *openness of mind*. Biology contributes to *moral openness of mind* by showing the importance of observance of law; even the amœba must obey the great biologic laws. Biology teaches, also, the interdependence of all organisms; life proceeds from life and is dependent on life. These reflections lead finally to the thought of GOD IN NATURE.

Biology contributes to *intellectual openness of mind* by furnishing the best of training in observation and comparison. The student learns to judge the relative value of different facts and the opinions based on them. The use of the microscope cultivates attention and exactness. Requirement by the teacher of definite and systematic notebook work enhances the profit from laboratory exercises. Biology broadens and clears the intellectual horizon by presenting information that serves as an admirable background for the study of many modern questions. "Take, for example, the fact that we have so many patent medicines, warranted to cure all aches and pains;

also the large number of quack doctors, who would not be in existence if they were not making money. Now, it occasionally happens that fake practitioners have well-informed people for their victims, but in the main it is the more ignorant class. We may well ask the question why this condition should exist. The answer is found in the following facts: Comparatively few people know the real cause of disease; it is all more or less of a mystery to them, and one fakir with a glib tongue and perfect assurance, using a pseudo-scientific mode of expression, forces conviction on the uncertain mind of the listener. So we find many strange views abroad concerning consumption and its supposed transmission from parent to offspring, while nearly every newspaper contains an advertisement guaranteeing to cure it. Similar crudities exist in regard to most of the common diseases. A general course in biology may very properly, while treating of bacteria, discuss their relation to disease. We believe that this would materially assist in establishing a saner appreciation of the laws controlling our own bodies and give to the well trained physician rather than to the fakir the remedying of disease."

Aesthetic culture, or openness of mind, exists to the degree in which a man's mind is open to the details of the beautiful and able to place them in their proper relations. One student is born with more, another with less of the æsthetic sense, but it is possible to develop in both a large measure of appreciation of the beautiful. Biology does this, either by creating an interest in the beautiful that leads to detailed study and fuller appreciation of what has already appealed to him, or by revealing hidden beauty in objects which he has approached from a purely utilitarian point of view. In either instance it is not long before the student is observing nature "with an eye made quiet by the power of harmony." The speaker defended this position by illustrations from the study and observation of the habits of birds and the fertilization of flowers by insects.

Discussion: Gertrude S. Burlingham, Binghamton High School.

One possesses culture in proportion as he is in touch with the life about him. Biology is the only subject in the high school that brings the student into direct contact with the life of which he is a part. Beside giving culture, biology opens the mind to an appreciation of the best in literature and art and lends a new meaning to history.

Students, as a rule, dislike to think. They prefer to have some one think for them. Sometimes it is the textbook that fulfills this function; again it is another student; sometimes it is the teacher. Biology, properly taught, will make the student do his own thinking, and he will grow to like to think for himself. Next to thinking, most high school students dislike accuracy. It is easier to say *very small* or *very many* than to give exact size and number. The study of biology should develop a love of accuracy. The laboratory and class work must be so conducted as to make other than original, independent work impossible. The field and laboratory work should educate the power of quick and accurate observation. Lastly, the study of biology should act in the mind as a ferment which time can not kill, so that the mind will be stimulated to reach out for more knowledge at each opportunity, until it attains more nearly the standard of a perfect culture.

Exhibition of a Living Frog Whose Cerebrum Was Removed Four Years Ago, by Dr. Burt G. Wilder, Cornell University.

The frog is apparently healthy and digests without difficulty food, which has to be introduced well down in the animal's throat. The frog performs several "stunts," like swimming, turning over when placed upon his back, etc. It is a source of sorrow, however, to the professor that the frog cannot reciprocate the attachment which four years of companionship has bred in its owner's heart.

SECTION A—PHYSICS AND CHEMISTRY.

EDWARD S. BABCOCK, ALFRED UNIVERSITY, CHAIRMAN.

Prof. Howard Lyon, of Oneonta Normal School, read the principal paper, "Fundamental Things in Physical Science," an abstract of which is given below. At the Round Table conference which followed, Prof. William Bennett, of Rochester, presided. The work was a general discussion of devices helpful in the class room and the laboratory. By general consent the meeting was voted most profitable to all.

As physical science must be regarded as a foundation upon which other science is developed, or, rather, as other science in the light of recent knowledge seems to be but a continuation of the study of physical science, it is important that this foundation be laid well and strong.

One who surveys carefully the field of popular physics is surprised to find that the number of fundamental ideas and principles is very small, and if a teacher has instructed his class thoroughly in these he is quite apt to be disappointed by the seeming meagerness of his work. However, no effort contributes so much competency in students as thorough grounding in those conceptions that form a basis for larger thought.

Ideas should be driven home by repeated examples, by questions, by experiments, and especially by constant appeal to early experience.

I take it that the work in physics in the high school and in the first year or two of the college course has to do largely or wholly with thorough instruction in what may be termed familiar principles such as were worked out with great care by early investigators and such as have to do with the phenomena of every day life.

In glancing over the large array of new texts in physics one is impressed with the idea that these works are leading students farther and farther away from the always attractive and severely plain works such as the old Comstock's *Natural Philosophy*. Newer works are very fascinating to one who has become familiar with the facts simply stated of the older writings, but are bewildering to the student who has just begun his study of physics. It seems a matter of regret that we no longer have such an illustration in physics as Pascal's bursting cask, for that picture kept one wondering until he finally understood the principle of hydrostatic pressure. We miss, too, the picture of Franklin storing his Leyden jar with electricity from the clouds. Perhaps the vague notion in the mind of bookmakers is that the picture would thwart the tendency of the modern student to discover for himself the relation between the cause of lightning and electricity.

It would seem sometimes as though we were assuming that the children of this later day were quite as wise as the mature Archimedes. As a matter of fact, it requires a good deal of drilling of an eighteen-year-old high school student to give him a sufficient grasp of Archimedes' principle to last him six months.

My wish is not for a return of the good old days, but for a continuance of what was valuable in early teaching. The older books contained but few elementary principles, but these were effectively illustrated by word and graphic pictures. Perhaps an analogy may be found in the oldtime reading of very few books but reading these thoroughly.

The superiority of students trained in the meagerly equipped country schools over those who are given the advantage of splendid city high schools confirms our opinion that long contemplation of relatively few objects of interest furnishes a better means of strengthing the mental processes than acquaintance with a maze of bewildering sights.

My acquaintance with papers in physics and chemistry of candidates for State life certificates in New York State convinces me that the amount of definite knowledge shown by high school, normal school and college students is often all too meager to merit the conclusion that these students are fairly educated.

If the question calls for a drawing and explanation of the principles of the telephone, there is presented a nebulous picture with a few remarks to the effect that, as the person speaks into the transmitter, a thrill of vibration agitates a hundred miles of wire with a message of sympathy to the distant listener, all of which rather suggests that our critics are wrong who begrudge us the time devoted to physics that it may be employed in the humanities.

It is not my purpose to facetiously criticise the results of the teaching of physics, but I know from the perusal of papers coming from the various quarters of the State that sound training in fundamental things is not all that could be desired nor all that is possible.

To better illustrate my contention that students of science are woefully deficient, at least those who are striving to obtain first grade or life certificates for teaching, I will read a few actual answers.

To the question calling for an illustration of the fact that a vacuum will not transmit sound, the answer was:

"Put a man in a zinc box, exhaust the air, and make him holler."

Another answer: "A planet has a tendency to move backward in its orbit. This is known as the planet's retrograde motion."

"Roemer discovered the velocity of light by observing Jupiter's satellites and noting the time that elapsed after the satellites were discovered with the telescope before they were first seen by the naked eye."

"To repair a dislocation requires two persons, one to hold the leg and the other to pull it."

The properties of nitrous oxide: "If breathed for a short time it produces unconsciousness, from which, however, the victim recovers with shouts of laughter."

What can be done to improve the teaching of physical science?

First, I would urge the judicious selection of topics of study by the application of common sense to the adaptation of the course of work to the experience and interests of youth.

A prominent teacher of physics remarked to me recently that a certain city that chose its instructors by competitive examination wholly was, in his judgment, making a serious mistake; for men with doctor's degrees were taking the positions and attempting often to do just the work in physics or chemistry that last engaged their attention in the university. He believed that plenty of men and women could be secured who had been tried thoroughly in the school room and whose power to adapt work had been abundantly proven.

I am acquainted with two teachers of more than average ability who have been trained in a leading university and who did the work in physics in that institution entirely to the satisfaction of their instructors, who say that when they began to teach they knew almost nothing of simple high school physics and were at a loss to know how to begin their work. They had been working on constants and coefficients and specific values whose meaning they only vaguely comprehended, and training in popular physics had been neglected.

However, much work of the sort mentioned above is needed in the technical schools. It is evident that the average citizen should be trained first in the physics of the lever, of fluid pressure, of expansion by heat, and of kindred familiar principles.

It is by no means true that physics and chemistry are not finely presented in many schools.

I have just had the pleasure of inspecting the splendid work in science of such institutions as the Teachers' College in New York, of the Erasmus Hall High School, and Pratt Institute, in Brooklyn, of the Binghamton High School, and similar institutions, and I found in these places a real delight in scientific research shown by the young men and women in attendance.

Here and there in small union schools I know that superior instruction is afforded in science, because teachers possess the knowledge and tact to adapt work to the student seeking instruction.

At the Teachers' College I saw working models of hydraulic elevators and of other commercial devices in use about the institution, all of which illustrates the point that I would make, namely, that the study of science should afford explanation of the devices and phenomena that are right at hand and familiar to the experience of those taught.

The preface to the first edition of T. J. Dorman Steele's *Fourteen Weeks in Chemistry* says that the author "has not attempted to write a reference book lest the untrained mind of the learner should become clogged and wearied with a multitude of details. . . . Unusual importance is given to that practical part of chemical knowledge which concerns our every day life, in the hope of bringing the school room, the kitchen, the farm, and the shops into closer relationship."

With such a purpose on the part of the author, it is fortunate that his works won so large a measure of popularity.

I will confess that I have but little interest in those queries that run: How can a student be best prepared to pass college entrance examinations, or regents' examinations, or examinations licensing candidates to teach? I believe in that sort of common sense preparation that will enable one to pass any reasonable examination through acquired ability to reason and sound and definite information.

We are here to discuss the best methods of teaching that we may fit students to go on to larger study or to take up intelligently the still larger problems of life.

Our task is distinctly that of laying a good foundation.

It must be borne in mind that any course that does not hold a student rigidly to a perfectly definite line of propositions must fall short of the best results.

Something of consequence should be presented, but, whether the amount be much or little, a firm mastery of that must be attained.

First books in physics are made valuable by heavy type head lines that fix and hold attention to fundamental ideas.

I valued very much the suggestion which Prof. Josiah P. Cooke, of Harvard, used to offer concerning laboratory books in chemistry when he said: "Use flaming head lines to express your idea of the importance of the results you secure."

It is desirable that a textbook should be small, not too wordy, and the explanation by the teacher should be brief, except in the abundance of illustrations.

The points made should stand out prominently. Clear, strong statements in the best possible English count most, and their mastery by the students should be proven by close questioning that would show beyond a doubt that the principle was understood.

Having been mastered, its staying qualities should be tried at intervals by review problems to which the principle is applicable. Teachers need

constantly to be on guard when presenting work to students lest they mistake their own enthusiasm and proficiency for that of the students.

I have heard college specialists say that they would prefer to have students do the beginning work in the various branches of science in the college. Beginning work must be done somewhere.

Why may this not be done splendidly in secondary schools by well trained teachers who possess knowledge, enthusiasm and common sense?

Those whose work ends in the high school should have an opportunity to study physical science, and others who are preparing for college may be so well trained that the college instructors will be aided by the thorough fundamental preparation.

Probably it is not training elsewhere that is objectionable, but insufficient training.

I believe that one can not attach too much importance to the use of cross-section drawings as a means of bringing out clear thought.

Good English speech and the power to illustrate and construct must ever be to the world satisfactory evidence of acquired power.

Finally, to be able to distinguish between essentials and nonessentials and to rate everything at its proper value is a high art everywhere recognized as a sign that its possessor is an individual of force and usefulness.

In this discussion I have made only a simple plea for the best possible training of youth that they may be able to understand a science of wonderful beauty and meaning to all who have dreamed of the something that underlies all reality.

On Tuesday morning the section meetings preceded the general session. At 9:30 Prof. O. C. Kenyon opened his new physical laboratory and machine shop for inspection by visitors. Apparatus was prepared and exhibited for about ninety laboratory experiments, fifty of which were performed during the hour by the high school pupils. In the machine shop were shown about twenty-five operations useful in making and repairing apparatus. Steam is supplied directly from the boiler in the basement and will be distributed to each pupil, like gas, water and electricity. Incandescent lamps are used in experiments with photometers, lenses, etc. Electricity is furnished by a dynamo of twenty volts E. M. F. and twenty amp. current. A new method of working with Atwood's machine was shown. Two principles were stated, with illustrations: (1) The best apparatus is none too good; (2) of two experiments, the one giving the more accurate result is to be chosen, even when it is less direct and simple in its method than the other.

At 10 a. m., in the physical laboratory, Prof. Ernest R. von Nardroff, of Brooklyn, exhibited a new apparatus for illustrating color experiments with the lantern. The lecture was one of the most attractive presented at the meeting. He was followed by Prof. W. C. Peckham, of Brooklyn, who gave a demonstration of the new element, radium. The speaker had a large collection of radio-active material, including a high potential radium salt specially imported for the occasion, and a spintharoscope. Both lectures received rapt attention by an appreciative audience which packed every available inch of room, even behind the lecturers' desk, and overflowed into the hall.